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MANUSCRIPT REPORTS

The Oil Prospect

D.C. Ion
Peter R. Odell
Bijan Mossavar-Rahmani

March 1984

The Energy Research Group consists of eminent members of the international community of energy analysts and policymakers from developing countries. This independent Group has been set up to review energy-related research and technology and its relevance to developing countries, to assess the research capacity of developing countries, and to suggest the priorities for energy research in these countries.

THE OIL PROSPECT

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INTRODUCTION

Ashok V. Desai

Coordinator, Energy Research Group
P.O. Box 8500, Ottawa, Ont., Canada

All energy resources (including such widely diffused ones as solar and wind energy) show great regional variations in availability and exercise a localizing influence on economic activities based on them. The lower their cost and the lower their transportability, the greater is their localizing influence. Oil is eminently transportable; its refined products fuel vehicles that can be considerably miniaturized; and, in the quarter century following World War II, it became progressively cheaper. As a result, oil proved a powerful force in the diffusion of economic growth, and in the industrialization of developing countries. The sharp increases in its cost in the past 10 years have, by contrast, jeopardized the growth of a large number of developing countries and brought some of them to the verge of bankruptcy.

Questions regarding the future of oil supply and prices are therefore of great relevance to developing countries and to the work of the Energy Research Group, whose task is to review the energy problems of developing countries and to assess the adequacy or inadequacy of the research and technology available to solve the problems. For this reason, three eminent experts on the oil question were asked to give their views on the prospects of oil. Their papers, presented at the Energy Research Priorities Seminar held on 8-10 August 1983 at the International Development Research Centre, Ottawa, are put together here.

Mr D.C. Ion summarizes the best available estimates of oil and gas reserves and output. On oil demand, he is more tentative, which is not surprising in view of the strongly lagged and unsteady response world oil demand has shown to price changes. On the future course of oil price, he points out that the number of major oil exporters is likely to shrink as time passes and the proportion of Saudi Arabia's exports in the OPEC total is likely to rise, giving that country increasing influence on the price.

Professor Peter Odell deals altogether more forthrightly with demand, which in his view is so price-elastic that different price regimes can give vastly different rates of oil exhaustion. As he points out, the marginal cost of producing oil must increase with the proportion of world oil resources that is exhausted, and hence its course over time must depend on the rate of exhaustion of oil. The higher the price of oil, the lower will be its demand, the slower the rate of its exhaustion, and the lower its marginal cost at a given time in the future.

So much is straightforward economics. Professor Odell's views, which were once sensational and are even now controversial, relate to the oil resource base. His figure of oil reserves is little different from -- and indeed lower than -- Mr Ion's. However, in his -- basically reasonable -- view, these are not the ultimate oil reserves, which must depend on, and increase up to a point with, investment in exploration and technology. The known reserves (including those used up) are of the order of 1600×10^9 barrels, and 2000×10^9 barrels is the minimum magnitude of ultimate reserves of low-cost, conventional oil. Professor Odell takes a likely estimate of 3000×10^9 barrels and another 2000×10^9 barrels of high-cost oil, and obtains consumption curves that show

oil lasting beyond the year 2080. Even without accepting his precise figures, it is possible to argue that liquid fuels in various forms can retain a significant place in development patterns and life styles for five or ten decades, and perhaps longer.

Professor Odell shares the view of Mr Ion that oil prices are determined by collusion between the major producing and consuming countries; in his view, they have combined to fix so high a price that the ultimate demand for oil may fall short of the ultimate reserves and that the oil industry may die for lack of demand. This view relies closely on Professor Odell's impression of a high price-elasticity of demand.

Dr Bijan Mossavar-Rahmani takes a different view of oil price formation. In his view, the world oil market is fragmented, and what is regarded as the world price of oil is only the price of the small proportion of oil exported by OPEC countries. Major consuming countries give preference first to indigenous oil and then to oil from safe sources -- which the OPEC countries are not, in their view. Hence the demand for OPEC oil varies more violently than total demand and so does the price of their oil.

Between them, the three authors have clarified some of the basic facts of the world economy, but they have also raised a number of issues that call for discussion. It is to invite such discussion that these papers are being brought out for wider circulation. The Energy Research Group would be keenly interested in all reactions to these papers, which it hopes will evoke a fruitful debate.

PETROLEUM AND THE DEVELOPING COUNTRIES

D.C. Ion

Energy Resources Analyst and Consultant,
Bledington near Kingham,
Oxford, OX7 6XQ, England

Introduction

The years 1973, 1979, and 1983 are three important dates in the continuing saga of the petroleum industry's uncertainty that replaced the relative stability of the late 1950s and 1960s, after the industry had weathered the "shock" of the temporary loss of oil supplies from Iran in the early 1950s. Rising world demand determined world supply before the 1973 oil shock, and only some oilmen (Bridgeman 1963) appreciated that because the oil resource was finite it could not sustain an exponential growth in demand for very long.

The oil shock of 1973 was, first, the interruption of supplies to some countries on the decision of the Arab Oil Ministers, followed by the rise in prices by the Organization of Petroleum Exporting Countries (OPEC). This burst the popular euphoric bubble that oil would continue to be cheap and to be the ever-expanding world energy source. There was an immediate over-reaction outside the oil industry. The producing countries soon thought that they had proved their power and would reap the benefit of great wealth that would put them on an equal footing with the industrialized countries, from whose exploitation some considered that they had suffered for decades. The consuming countries feared for the security of their supplies of oil on which they had come to rely heavily. The world financial circles feared the threat to their establishment by the switch of enormous funds into new hands and wondered how best to absorb the new "petrodollars."

The oil industry reacted first to mitigate the supply discontinuities. This was possible because the major international companies still had their traditional flexibility through integrated company control systems and had a belief in the sanctity of contracts. These majors were older than all governments and most countries. Their staff had coped with many crises in many countries. Indeed they had been so successful that the world had enjoyed 20 years of stable prices and increasing supply. That critical period of late 1973 and early 1974 saw the last of the obvious stabilizing power of the major oil companies. The increasing invervention of governments and politicians, the increasing influence of bankers, investment brokers, commodity speculators, and the public, with its new concerns like environmentalism, have caused a restructuring of the petroleum industry to meet these changes and the world economic recession. The year 1973 marked the end of the era of cheap energy. The possibility of supply interruptions stimulated exploration for new sources outside the OPEC area, a drive for improved efficiency, and a search for energy sources alternative to oil.

Fears for the world financial structure proved unfounded: economies started to adjust; demand for oil started to rise and the depression to lift. Significant amounts of oil began to develop from new sources, particularly in Alaska and the North Sea, and the decline in USA production was halted in 1977. However, the fragility of the revival was shown by the over-reaction of the oil industry, as well as the consuming countries, to the overthrow of the Shah of Iran in December 1978.

Iran was producing 285 Mt/year in 1977 and supplying natural gas to the USSR. There were schemes for supplies of gas and liquified natural gas (LNG) to a total of some 40 x 10^9 m^3, the equivalent of another 34 Mt/year of oil. The Shah's appreciation that oil was wasted under boilers, and that nuclear energy could be an element in the energy mix even of an oil-producing country, had given hope for the development of rational energy policies. There

was, therefore, in December 1978 not only the loss of a major oil supply, but the overthrow of a western type of energy system and the threat that an Islamic revolution might disturb the whole of the Middle East.

Almost overnight, the oil market was transformed into a frantic scramble for supplies. OPEC followed the newly developed "spot market" and found that buyers would pay higher prices. Later, the confusion caused by the struggles of the Khomeini regime was confounded by the Iran-Iraq war from September 1979.

Crude oil prices of Arabian Light, the OPEC marker, were some $2/US barrel (pb) in 1972, jumped to almost $11 pb at the end of 1973, to $26 pb by the end of 1979, and then up to $34 pb by the end of 1981, a price that officially held through to early 1983.

The 1979-80 rises halted the recovery in the world economy, dealt a heavier blow to those developing countriea that had little or no oil or alternative energy sources, encouraged energy conservation and substitutes for oil in the industrialized countries, and stimulated further the search for and production of new non-OPEC oil and gas. The call on OPEC oil was markedly reduced.

OPEC production of crude oil, plus natural gas liquida (NGL), fell from 1.35 Gt in 1980 to 1.14 Gt in 1981, to 0.96 Gt in 1982, and continues to fall. These were falls of 15.7% and 17.5% while world production fell only 5% to 2.75 Gt. OPEC found by March 1983 that their official price scale, based on Arabian Light Crude at $34 pb, could not be held, because members were both price cutting and exceeding their agreed production quotas. Supplies to the market were augmented by reduction in stocks in anticipation of prices falling, as they did when OPEC set a new marker price of $29 pb. Spring 1983 therefore saw the first significant fall in the official OPEC crude price since 1973. The fall was due to market forces and, though foreseen for many months, the consequences were still unclear in May 1983.

This recapitulation of the events of the past decade is intended:

- To stress the turbulence since 1973 and some of the factors that have formed the present base from which the future must be viewed;
- To give a coherent summary, while appreciating that every reader would have told the story differently, according to his own viewpoint;
- To emphasize that people often react in anticipation of events that might otherwise never happen;
- To stress the need to take a global overview, because the developing countries cannot be considered in isolation - the term "the Third World" implies a First and Second World, but in energy resources there is only One World.

Nonetheless, a grouping has to be adopted for discussion and four groups have been taken, the industrialized countries (taken as the Organization for Economic Cooperation and Development, OECD), the centrally planned economies (CPE), OPEC, and the less developed, non-OPEC developing countries. This grouping is far from ideal because, over the past decade, there has been increasing differentiation within the developing countries with the growth of the newly industrialized countries of South Korea, Taiwan, Brazil, Argentina,

Hong Kong, and Singapore. This group already had, in 1975, a per capita energy consumption of 1157 kg of coal equivalant (kg-ce), compared with the 98 kg-ce for the other developing countries and 5016 kg-ce for the industrialized old countries (Gordon 1980). Saudi Arabia claims that it will have semi-industrialized status by 1985 when its steel and petrochemical projects come on stream, and the manufacturing share of Gross National Product (GNP) will be 55%.

Four aspects of the problem of petroleum availability will now be discussed: supplies of conventional petroleum; supplies of nonconventional petroleum; the demand and need for oil and gas in the energy mix; and oil resources and oil prices as illustrative of the scenario that emerges.

Availability Of Petroleum Supplies

Crude oil

The best known sector of the world's petroleum resources is the Proved Reserves of crude oil: at the end of 1982, these amounted to some 32 times the 1982 production. These Proved Reserves are supported by Unproved Reserves, both Probable and Possible, and by Speculative Reserves, and all three add up to the Ultimate Potential Recovery, which is perhaps, after deducting past production, 85 times 1982 production.

Ultimate Potential Recovery is a concept that is often estimated and always controversial. There is no doubt that increasing effort will be required to discover and prove the great amount of oil and that that exists but geological concepts change and engineering capabilities improve. The implications of the movements of the plates now considered to form the continents are not fully known. The latest depth record of water above a drilled well is some 1714 m, whereas 200 m was taken as the limit only 25 years ago.

In recent years, there have been many descriptions of prospects of non-OPEC developing countries, in many journals and books, and there has been marked increase in exploration activity since the middle 1960s in many countries. There have also, perhaps unfortunately, been some estimates based on drilling density comparisons that have not given due weight to the infinite variety of nature and the undoubted differences in richness of different basins. Such suggestions can mislead by raising unjustifiable hopes of instant riches. Similarly, the attribution of lack of exploratory effort and low resource estimates to Machiavellian motives of the major oil companies really only allow some countries to set up a scapegoat and forget that it was their own nationalist policies that precluded exploration by the technically and financially equipped foreign oil companies and resulted in their present position with unknown and undiscovered oil resources. These resources are indeed unknown in many instances and their future potential estimates are pure guesses.

However, current Proved Reserves data are adequate for discussion of the short- and medium-term future. Proved Reserves may be defined (Study Group Report, World Petroleum Congress, 1983, London) as:

> The estimated quantities, as at a specific date, which analysis of geological and engineering data demonstrate, with reasonable certainty to be recoverable from known reservoirs under the economic and operational conditions at the same date.

The definition indicates that judgement is involved. That judgement may be affected by pride, prejudice, and politics. Hence even the best known reserves category can only be an estimated aggregation of data hopefully close enough in calculation to be a valid discussion entity. The reiteration of the date in the definition emphasizes that reduction by production and additions by development are constant dynamic elements in all such estimates.

Table 1 gives the position of Proved Reserves of crude oil at end 1982, production in 1982, and consumption in 1981 (sic), on both a geographical and political basis.

The problem with world oil reserves is less their totality than their maldistribution through distance from the main industrial markets, which were based originally on indigenous coal. OPEC dominates with 67% of the world Proved Reserves and of this, geographically, 82% are in the Middle East, so that the Middle East dominates with 55% of the total world - Saudi Arabia, having 44% of the Middle East reserves, has 25% of the world's. In Latin America, the bulk of the 11 Gt Proved Reserves are the 6.6 Gt in Mexico and 3 Gt in Venezuela. Mexico also has 6.6 Gt of the 10 Gt of the Less Developed Countries (LDCs) outside OPEC.

The weight of the Middle East Proved Reserves in giant fields with prolific and low-cost producing wells is a factor of great power, whether used within the framework of OPEC or by Saudi Arabia alone.

Table 1. World Proved crude oil Reserves (end of 1982), Production (1982), and Consumption (1981)

	Proved Reserves		Production		Consumption	
	Gt	%	Mt/year	%	Mt/year	%
Geographic						
North America	5	5	494	19	825	28
Latin America	11	12	305	11	228	8
Western Europe	3	3	141	5	630	22
Eastern Europe and USSR	9	10	632	24	546	19
Africa	8	9	222	8	76	3
Middle East	51	55	632	24	85	3
Asia	5	6	232	9	512	18
Political						
OECD	8	9	654	25	1700	59
CPE	12	13	732	28	648	22
OPEC	62	67	929	35		
LDCs outside OPEC	10	11	335	12	554	19
WORLD	92	100	2650	100	2902	100

Source: Oil and Gas Journal, 27 December 1982.

Table 2 shows the OPEC Proved Reserves, Potential Productive Capacity, and population by member countries. The disparity between members is important. The oil reserves range from 22 Gt to 0.06 Gt, but population ranges in a very different order from the 129 million people in Indonesia to the 0.2 million in Qatar. These differences lead to problems of reconciliation of national aims among OPEC members, while in the Middle East political rivalries are not confined to the current overt war between Iran and Iraq.

Table 2. OPEC Proved oil Reserves (end of 1982), Potential Productive Capacity, and Population (1974)

	Proved reserves (Gt)	Potential productive capacity (Mta)	Population (millions)
Saudi Arabia	22.4	540	9.0
Kuwait	9.2	140	1.0
Iran	7.6	150	33.0
Iraq	5.6	75	11.0
United Arab Emirates			
Abu Dhabi	4.2		
Dubai	2.0	125	0.5
Sharjah	0.06		
Venezuela	3.0	120	12.0
Libya	3.0	100	2.5
Nigeria	2.3	120	61.5
Indonesia	1.3	80	129.0
Algeria	1.3	50	16.5
Qatar	0.5	30	0.2
Ecuador	0.2	10	7.0
Gabon	0.06	10	0.8
TOTAL	62.72	1250	284.0

Sources: Proved reserves -- Oil and Gas Journal, 27 December 1982 (7.3 US barrels = 1 t);
Potential productive capacity -- US Department of Energy Study 1982 (Petroleum Economist, London, UK, February 1983); Population -- "The World in Figures," The Economist, London U.K., 1976 (values rounded up).

Column 2 of Table 2 gives the estimated of potential production, base on 1979 data and given in a 1982 US Department of Energy study. Dr. Taher, Governor of the General Petroleum and Mineral Organization (PETROMIN) of Saudi Arabia, gave a potential of 600 Mt/year for Saudi Arabia (Taher 1982) and continued that figure through the year 2000 in his optimistic scenario that reflects cooperation between oil producers and consumers, although his total OPEC production fell from 1700 to 1300 Mt/year in 2000 -- so stressing the Saudi importance.

It is against these potential figures that one should consider the actual OPEC production for 1973, 1976, 1979, and 1982, and the March 1982 quotas given in Table 3, particularly, to appreciate:

- How the aspirations of OPEC members have been unsettled by the fall in world demand, since 1979 in particular, for their oil;
- The obvious problems faced in setting the March 1982 quotas; and
- The contributions that the members could make if demand was there.

Table 3. OPEC crude oil Production (Mt), 1973, 1976, 1979, 1982

	1973	1976	1979	1982	March 1982 quotas
Saudi Arabia [1]	382	434	485	331	250
Kuwait [1]	154	110	128	40	52.5
Iran	293	295	158	95	120
Iraq	99	119	171	46	60
United Arab Emirates					
Abu Dhabi	63	77	70	44	
Dubai	11	16	18	18	55
Sharjah	0	2	0.7	0.35	
Venezuela	179	123	125	91	83
Libya	105	93	101	56	55
Nigeria	100	103	114	66	65
Indonesia	66	75	79	67	65
Algeria	51	50	57	37.5	36.5
Qatar	27	24	25	17	15
Ecuador	10	9	10.5	11	10
Gabon	7.5	11	10	6.5	7.5
TOTAL	1547.5	1541	1552.2	926.35	874.5

Sources: 1973-1979 -- BP Statistical Review, 1981; 1982 -- Oil and Gas Journal, 27 December 1982 (7.3 US barrels = 1 t);
March 1982 Quotas -- Petroleum Economist, London, U.K., April, p. 118.

[1] Includes half the production of the Partitioned Neutral Zone.

Production tables, like Table 3, imply that all tonnes of oil are of equal value, but they are not. Crude oils vary greatly in characteristics that are not only reflected in different prices but also affect availability. Where countries have more than one type, they attempt to ensure that the heavier crudes, which are less easily refined into the higher, more valuable product fractions, are not left unsold, but are sold in the ratio with lighter crudes proportional to their reserves.

There are currently some 13 oil-exporting non-OPEC developing countries but, except for Mexico, their reserves and production are globally insignificant but domestically very important.

Mexico has had a long and chequered petroleum history that provides excellent examples of the physical, social/political, and economic factors that affect crude-oil availability and must be considered in any research into such matters. Mexico's first peak production in 1921 at 26.5 Mt/year was second only to USA in the world, but then fell to only about 4.4

Mt/year in 1932 as the prolific fields of the Golden Lane were depleted. The industry was nationalized in 1938 and then began a long, slow, hard climb back, until in the early 1960s, the rich new southern provinces and then the rich offshore fields in the Gulf of Campeche were discovered and exploited. The 1921 peak was equaled in 1973 and production increased fivefold to 137 Mt/year in 1982. Mexico, like Norway, usually publishes its petroleum reserves as an aggregate of oil and gas in terms of oil equivalent. This can be misleading. However, its Proved Reserves of crude oil increased from 1.24 Gt at the end of 1977 to 6.6 Gt at the end of 1982. The increase was due not only to the southern additions but also to 1.5 Gt attributed to the Chicontepec area of the central region. The reservoirs here are very different from those in the south. Individual well productivity will be low, thousands of wells will be required, and so the drilling effort will be long and costly -- another example that all reserves are not equal. Nonetheless, with exploration in all areas far from complete, Mexico is already in the Iran/Iraq category of Proved Reserves, and could be capable of a production of 150 Mt/year for 40 years, or a very much higher production for a shorter period. The long, hard, and virtually unaided struggle has made the Mexicans determined to produce only as much oil as they consider necessary for Mexico's needs as they judge them. They will not repeat the overproduction of the 1910s. They will not become overdependent on one outlet, even to their big neighbour, the USA. Their recent financial problems are due to overborrowing in the expectations, shared by the bank lenders, of increasing production and higher prices. Nonetheless, they have collaborated with Venezuela in a scheme to offer favourable crude sales terms to their Latin American neighbours who would invest in exploration for their own indigenous petroleum resources. They therefore both diversify their outlets and held the economic stability of the area.

No other non-OPEC developing country is self-sufficient in petroleum and, until they become so, each will be dependent on imports varying according to the size of that element in the energy mix that they develop as best suited to their own needs. Are there other sources for those imports than OPEC or, to a more limited extent, Mexico?

The industrialized nations of OECD had only 9% of the world's Proved Reserves of oil at end 1982, but 59% of the 1981 consumption (Table 1). OECD in total will be a net importer for very many years. Individual exceptions will be the UK, for several years, and Norway for longer, but the natural markets for any surplus are Europe and the USA. The US domestic production of conventional crude oil peaked at 482 Mt/year in 1970 but has been held around the 433 Mt/year mark since then, mainly because of the Alaskan discoveries. Whether this level of production can be maintained will depend on the development of potentially prolific "plays" such as offshore California and in the Overthrust Belt of the Rockies. New geological concepts and improved drilling and production techniques can lead to new discoveries even in a country as well explored as the USA. However, despite new discoveries in the USA and other OECD countries, it is very difficult to see how the OECD area will have surplus oil for export to the rest of the world from conventional sources.

The Centrally Planned Economies (CPE) do not publish reserves data. The estimates of Table 1 show the CPE to have 13% of world Proved Reserves, 27.5% of production, and 22% of consumption. The bulk of these is in the USSR. Estimates of the Proved and Unproved Reserves of the USSR range from 5 Gt to 50 Gt; nevertheless the 8.6 Gt in Table 1 is probably a low estimate. The USSR, however, may be expected to tailor its consumption of crude oil in the energy mix to allow some export to Comecon, for political reasons, and to the West, for economic reasons, to earn hard currency. Despite an American report of 1977, it would seem probable that Soviet oil production may plateau in the 1980s but rise again in the 1990s as the

necessary infrastructure is built to allow the exploration and expoitation of the sedimentary basins of Siberia. Certainly there is little likelihood of the USSR being able to export large amounts of oil, nor need to import large amounts, in the short and medium term.

The People's Republic of China also does not publish reserves data. Estimates of Proved and Unproved Reserves have ranged from 3 Gt to 30 Gt. The figure used for Proved Reserves in Table 1 is 2.7 Gt. China is in a very early stage of exploration. There are good prospects offshore, but the speed of their exploitation after discoveries will be subject to political direction. Hence, with the very large potential domestic market, it is again unlikely that much oil will be available for export.

In brief, oil supplies for the non-OPEC developing countries are most likely to be available from new indigenous discoveries or from OPEC, particularly from the Middle East, and, perhaps to a limited extent, from Mexico.

Natural gas

The Proved Reserves of natural gas are more widely distributed than those of crude oil, but supplies are less flexible. Table 4 shows the 10-fold growth in published Proved Reserves from 1950 to 1982, particularly in the USSR whose Proved Reserves at end 1982 were estimated at 32 Gt oil equivalent (Gt-oe) and so 41% of the world's 77 Gt-oe. The Middle East is second with almost 20 Gt-oe, or 25% of world Proved Reserves in contrast to having 55% of world Proved Reserves of crude oil.

Table 4. World natural gas Proved Reserves, end 1950, 1960, 1970, 1980 and 1982

	1950	1960	1970	1980	1982
Actual amount (Gt-oe)					
North America	4.77	7.30	8.47	7.21	7.7
Latin America	0.63	1.26	1.71	3.87	4.8
Western Europe	0.09	0.27	3.15	3.51	4.0
Eastern Europe and USSR	0.09	1.62	8.83	23.69	32.0
Africa	-	0.54	3.42	5.50	4.5
Middle East	1.62	3.96	6.13	16.85	19.6
Asia and Oceania	0.45	0.55	1.44	4.41	4.5
WORLD	7.65	15.40	33.15	65.05	77.1
Distribution (%)					
OECD	65	50	36	18	16
CPE	1	11	27	38	42
OPEC	25	35	32	35	33
LDCs outside OPEC	9	5	5	9	9
	100	100	100	100	100

Sources: 1950-80 -- Valais (1982);
1982 -- Oil and Gas Journal, 27 December 1982 (1 Mt oil = 39.2 billion ft^3).

The gas data of Table 4 must be viewed with caution, because all gas is not equally available -- the gas associated with oil is dependent on the rate of oil production. All gases do not have the same calorific value -- most gases contain some inert, nonflammable gases that may be a significant part of the total volume. In the USA, where the percentage of nonhydrocarbon gases is usually low, this is ignored because it is accounted for by the price being related to calorific value. In other areas, the percentage may be less than the possible estimation error. Nonetheless, the reserves figures must be treated as being indicators rather than absolute values. Furthermore, although there has been a marked reduction in the amount of associated gas being flared, there is much more wastage of gas than of oil.

A more important feature of natural gas is that its exploitation requires high investment in pipelines, both at the gathering and distribution ends, with either major trunk lines or, where ocean transport is entailed, special tankers for LNG plying between high cost liquefication and gasification terminals. Commercial investment in these fixed facilites means that specific long-term contracts are required to ensure continuous throughput: "spot cargoes" are uncommon. The size and location of the market is therefore vital in determining whether investment is warranted and therefore whether gas supplies are available.

The size of both the Soviet reserves and the West European market warranted the major pipeline systems installed and under construction. The gas market in south-west Russia, which grew as local oilfield production declined, warranted the major pipelines from Iran and Afghanistan. Similarly justifiable were the pipelines from southern Mexico to the USA, Algeria to Italy, and the LNG ocean trade from the Middle East to Japan. However, the LNG trade between Algeria and the USA foundered on price, which has been a hurdle on other deals as the gas producers seek parity with oil prices. Major LNG export schemes for Nigeria have only been talked about for many years, while Iran's schemes have been halted by revolution and war. World trade in natural gas has not grown as many expected in 1974-75, but major projects are still being considered. Two examples are the Spanish proposal to the International Energy Agency (IEA) in May 1983 for a $10 billion pipeline from Nigeria through Morocco and the Straits of Gibraltar to Western Europe, and the LNG schemes agreed in February 1983 for the development of the offshore North Field of Qatar, which has some 90 Mt-oe Proved and 200 Mt-oe Probable Reserves.

In general, therefore, the availability of natural gas supplies is restricted by logistics. An indigenous supply for local use is valuable, but imports into small markets may not be possible, economically or physically.

Availability Of Petroleum Sources As Alternatives To Conventional Petroleum

It is in this area that fact and fiction become most mixed in popular talk and writing. The alternative sources are those hydrocarbons that cannot be exploited by currently conventional means -- the very heavy oils, oil sands, oil shales, gas in tight formations, gas under high pressure, or gas occurring as gas hydrates.

Very heavy oils

There are many occurrences of very heavy oils in many countries, which may have a considerable total tonnage. The accumulations that are most discussed are those in the USA, Canada, and Venezuela, but other deposits include those in the USSR, Iraq, Madagascar, Sicily, and China. Techniques for their exploitation exist, but only very favourable local economics would make most deposits commercially viable on these techniques.

Oil sands

An indication of the oil reported to be recoverable from the better known of these deposits is given in Table 5. These are not Proved Reserves comparable with those of crude oil because only in Canada are oil sands commercially exploited or have been systematically assessed. The Tar Belt of the Orinoco Basin in Venezuela is an accummulation of oils that vary from heavy through very heavy to Natural Tars. The lighter types have been exploited for many years and schemes for increased explotation into the heavier types have been studied. However, as with the additional schemes for the Alberta Oil Sands of Canada, the schemes that were well advanced when oil prices were rising have recently been postponed; initial capital investment is high and costly when interest rates are high; lead times from start to production are long.

Table 5. Oil "Reserves" from some oil sand deposits, nominal values as of 1 January 1979

Country	Amount (Gt)
Canada	19.3
Venezuela	20.0
Jordan	0.7
Austria	0.05
USA	0.001

Source: World Energy Conference Survey, 1980.

Oil shales

The oil shale exploitation is similar to that of oil sands. The figures reported to the World Energy Conference (Table 6) indicated considerable resources, but again, although they purport to indicate oil recoverable under present conditions, they are not Proved Reserves in the strict crude oil sense.

Table 6. Shale oil reserves in some countries nominal values as of 1 January 1979

Country	Amount of recoverable oil (Mt)
USA	28000
USSR	6820
Federal Republic of Germany	250
Sweden	880
Spain	12
New Zealand	1
Morocco	7400
Thailand	2015
Jordan	800
Brazil	80
Argentina	0.045

Source: World Energy Conference Survey, 1980.

The "oil" in oil shales is in the form of solid kerogen that must be distilled to yield a liquid oil. The yield varies considerably from 12 to 400 L/t, which immediately indicates the enormous tonnages involved in any but very small operations. Some deposits vary greatly in richness and few have warranted the investigation needed to give good data.

Since the exploitation of oil shales in Scotland and Sweden was killed by cheaper imported oil, commercial use has only been in the USSR, particularly as raw fuel for power stations in the Baltic States, and in the People's Republic of China (PR China), where in the open-cast coal mine at Fushun, Liaoning Province, shale is excavated with the coal and is retorted.

In Brazil, a pilot plant has been running for many years. There is exploration work planned in Morocco but some of the reports confuse reserves of oil shale and shale oil. Jordan has had feasibility studies made of its largest deposit but exploitation is probably many years ahead. Thailand's shales have not yet attracted foreign capital and the government only plans for a small power plant using raw shale as fuel and a feasibility study for a small extraction plant. Australia is listed in the 1980 World Energy Conference Survey as having only 460 Mt as an additional resource, whereas it appeared that the first large commercial plant might be on the richest deposits in Queensland, which was said to have 2 Gt of shale oil resources and a production of 1 Mt/year was planned for the early 1990s. The project was postponed in 1981 as uneconomic. In the USA, with government help promised by the Carter Administration, it again seemed that commercial exploitation was close, but the Reagan Administration withdrew that promise of direct help and there is still no production.

Undoubtely there are many oil shale deposits that might be exploited by known techniques of mining, particularly open-cast mining, or even in situ methods that are still all in the experimental stage. Some deposits have been

looked at with help from the United Nations. However, the problems of exploitation must temper dreams to reality. For 50 years at least, it has been said that the potential oil from oil sands and oil shales would be a ceiling to the price of crude oil. This is a myth. There is still no commercial exploitation of even the richest of the deposits in the USA, despite the 15-fold increase in crude oil prices in the past decade.

Unconventional natural gas

The exploration for and exploitation of these sources are even more dependent than unconventional oil deposits on both funds and expertise that non-OPEC developing countries cannot be expected to possess. The deep geopressured zones of Texas and Louisiana are not yet commercial. Similar geological conditions may occur elsewhere but it would seem sensible to wait until methods of exploitation have been proved before spending much effort on defining such places. Gas hydrates are found in the permafrost areas of Siberia, and so need not concern countries in the tropics, and in ocean floor sediments of the deep oceans, where again high cost and expertise will be required for exploitation and only theoretical ideas as to methods have materialized. Nuclear explosions have been tried to extract gas from some very tight rocks but without commercial success. In the past few years, arguments have been put forward for the presence deep in the earth's crust of primordial methane that could supply enormous amounts of energy. These ideas are interesting speculations, but there are equally strong arguments against such gas being ubiquitous and the practicalities of specific accumulations adequate for exploitation have not been demonstrated.

In brief, therefore, there seems little likelihood for supplies of unconventional natural gas being available to petroleum-deficient developing countries for a very long time, if ever.

Demand And Need For Oil and Gas

As oil and gas are but two of the elements in the energy mix, the size of demand for them will depend on the total energy demand and on the need for them, both in areas where they are in competition with the other elements because of the possibility of substitution and in the end-use areas where they are essential and have little or no competition.

Total energy demand

Ever since the publication of "The Limits to Growth" (Meadows et al. 1972), macroeconomic models to forecast demand, both global and national, have proliferated. Few have done more than emphasize the importance of some factors: none have given a credible long-term forecast for which events in the short term have not altered the basic premises to such an extent that, despite the scenario technique, only generalities have emerged.

Wynne Godley (1983) wrote:

> Macroeconomics is in a state of deep confusion. The profession is deeply divided. So far from there being any body of knowledge which is generally accepted, almost every proposition is extremely contentious. Public discussion of economic policy has no coherent rationale and governments, notwithstanding their emphatic rhetoric, cannot give a credible explanation of how their policies will not achieve the results they seek, nor have they any basis for negotiation with one another.

Certainly, for the energy aspect, the main reason is ignorance of hard facts about the availability of supplies, the criteria on which demand may be assessed and the reactions that the market will have to new situations. The ignorance results in surprise at what happens, this causes uncertainty, which in turn results in aberrant actions, reactions, and consequences.

The developing countries number about 100; as a group, they represent nearly half the world's population, account for 25% of world economic output, and 15% of world commercial energy consumption (IEA 1982). Oil provides almost 65% of the commercial energy supplies. Breaking down these totals into significant groups for discussion on demand is difficult because of the variations in the characteristics of all countries, as instanced earlier and shown by every study choosing different groupings, which makes collation of facts extremely difficult. Here, however, discussion will be confined to OPEC and non-OPEC groups.

Organization of Petroleum Exporting Countries (OPEC)

By definition, oil is their main source of both energy and revenue and is traded as a commodity. Their domestic demand for petroleum depends not only on their population and stage of industrial development, but also, mainly, on government policy, which is itself dynamic.

Iran, Indonesia, Nigeria, Algeria, and Venezuela have relatively large populations (Table 1) and need high oil revenues to support economic development programs, but their ratios of oil reserves to production capacity are comparatively low. On the other hand, Saudi Arabia, The United Arab Emirates (UAE), and Kuwait, with relatively small populations, have been producing oil at more than domestic revenue needs and have accumulated surplus funds that they wish to safeguard from loss of value. Taher (1982) argued that, by cooperation between the oil-producing and -consuming countries, the time required for the producers to effect structural changes to raise their standards of living and attain economic and social stability could be matched to the rate of transition in consuming countries to a balanced energy mix, without over-dependence on oil. He chose three scenarios to illustrate the consequences of the three options that he saw as possible -- cooperation, neutrality, and confrontation. The figures used by Taher are given in Table 7, together with the ranges given for the Developing Countries by the International Energy Agency in their 1982 Outlook for Energy (IEA 1982).

In all three scenarios, Taher envisages OPEC consumption rising, being 27% of the world total in the cooperation scenario but only 18% in the confrontation scenario.

Libya illustrates the dramatic effect of recent loss of revenue and resulting actions that have affected OPEC and will continue to affect the oil-producing developing countries. Libya, with a population of around 3

Table 7. Actual and prospective crude oil and NGL consumption (MT) in developing countries

			1985			1990			2000		
	1987	1979	CP[1]	N	CF	CP	N	CF	CP	N	CF
OPEC											
(1)	75	110	210	185	170	345	270	220	830	505	305
(2)				195-180			275-250			435-375	
Other LDCs											
(1)	355	420	575	520	460	655	570	485	505	400	290
(2)				465-445			610-535			1050-825	
WORLD											
(1)	2850	3250	3620	3310	2954	3510	3055	2565	3075	2385	1695

Sources: (1) -- Taher (1982); (2) -- IEA (1982: 168-169).
[1]CP = Cooperation scenario, N = Neutral scenario, CF = Confrontation scenario.

million, saw its 1980 income of US $22.6 billion fall to $10 billion in 1982, even though, despite the agreed quota in March 1982 of 55 Mt/year, Libya was producing at the rate of about 90 Mt/year by the end of 1982. The action taken was to reduce development projects originally scheduled at $62.5 billion over 5 years, delay payment to contractors, and cut consumer-goods imports in the 1983 budget to 60% of the capital-goods imports for light and heavy industry. Similarly, Indonesia announced delays in four major oil projects in May 1983.

In contrast, Kuwait has become the first Arab producer to sell direct in the European market by buying assets of the Gulf Oil Company in Europe: assets that included 1600 retail outlets and two refineries. This restructuring started in 1980 and is just one indication of the sort of changes that must be anticipated when considering these and similar projections of consumption.

Non-OPEC developing countries

A middle-income subset of this group, that is those countries taken by the World Bank as having a GNP per person of at least US$360 in 1978, particularly the semi-industrialized countries, share many of the problems of the industrialized countries, with major dependence on oil and a need to increase efficiency in energy use. The low-income subset with a GNP below US$360 per person derive half their total energy from noncommercial sources but rely on oil for the bulk of their commercial energy. A major problem is that many of the non-OPEC developing countries do not have the "autonomous strength," as Taher puts it, to adjust easily to the new energy situation. The new situtation is illustrated by the rise in the cost of oil imports to the oil-importing developing countries from US$8.3 billion in 1973 to US$91.1 billion in 1980, with an outstanding debt increasing from US$ 97.4 billion to $370.1 billion according to the International Monetary Fund (IEA 1982). Relief can only come with a general revival of the world economy and increased exports into the industrialized countries.

Taher's scenarios are essentially based on pre-1979 thinking, whereas the IEA figures are post-1979. This explains the lower growth ascribed to 1985 and 1990 by IEA (Table 7) although their figures for 2000 are more optimistic. However, Table 7 has been included here to emphasize the following points:

- Demand and supply are inseparable;
- Demand and need are separable -- the price increases of 1973-74 and 1979 had a marked effect on demand and, by increased efficiency and substitution, reduced the need for oil, and some of these effects will be permanent; and
- The former close parity between economic growth and oil consumption has been broken.

Further, the post-1979 fall in demand has significantly affected supply:

- There is surplus production capacity in OPEC;
- Complacency as to future supplies has returned in some minds;
- Investment interest in alternatives to crude oil has dropped;
- The structure of oil refining has changed in that, although refining capacity is surplus -- because plants were constructed to a higher future demand level and refineries are being closed -- more upgrading capacity is being installed to provide more light fractions, because of the reduced demand, through substitution particularly by coal for heavy fuel oil for steam raising in power stations and industry; and
- A surplus of tankers has dropped freight rates and reduced the gap between short- and long-haul crude sources.

All these factors bear on the relative values of different crudes and natural gas, as well as on the total tonnages marketed. In the past, these factors have often been underestimated, but the arguments about relative crude oil prices in the first quarter of 1983 have brought home to many people, certainly in Britain, that different crudes have different values. It is important to remember this when considering any crude oil data and when considering oil prices, using a marker of Saudi Arabian Light Crude, as indicative of future oil supply/demand trends.

Oil Resources And Oil Prices

Even in 1980, many thought that oil prices must inevitably continue to rise, but by late 1982 some were predicting the possible collapse of OPEC-controlled prices. By mid-May 1983, the danger seemed to have lessened as producers saw the dangers of a price war. The optimists were seeing signs of world economic recovery, but few saw any but slow growth ahead for many years.

A slow economic recovery will mean a more gradual increase in oil demand because of the changes resulting from the oil shocks of the 1970s. If one assumes that a 4% per year recovery will mean a 2% per year growth in oil consumption in the world outside of the communist areas (WOCA), it would be 1990 before oil consumption equaled that of 1979 (Netschert 1983). Therefore, OPEC's peak production of 1565 Mt/year in 1977 may not be required until, at the earliest, the early 1990s because of the growth meanwhile of non-OPEC

production, from 765 Mt/year in 1977 to 1010 Mt/year in 1982 and increasing. Therefore, it could be the mid- or even late-1990s before there could be a "normal" supply shortage to push crude oil prices in real terms over the 1982 price of US$34 pb in 1982 dollars or $16 pb in 1972 dollars.

Demand could grow faster than 2% per year through more rapid economic recovery and complacency slowing down substitution and conservation. Saudi Arabia may show restraint in recovering its production rate from as low as 175 Mt/year estimated for May 1983, to its 1979 level of 470 Mt/year to accommodate the undoubted wish of the other members of OPEC, particularly Iran and Iraq, to recover their lost production. If these increases in production are made without a fall in prices, then there could be a semblance of stability. Oil prices would then rise only with inflation, if that continues to be a characteristic of world economics. This scenario would give the currently debt-ridden developing countries time to recover by selling into the expanding market.

If, on the other hand, the precarious balance achieved in March 1983 with effectively all producers avoiding a price war does not hold, then prices could plummet at least, perhaps, to a floor of the costs of say North Sea oil. It is difficult to see how world-wide financial and economic chaos could be avoided. This danger is appreciated and therefore, hopefully, is unlikely. At the other extreme, it also seems unlikely before 1990, that a sudden boom could materialize that would mop up the current surplus capacity and force up oil prices above inflation.

Resuming, therefore, the middle course, care must be taken that the capacities of Table 2 are not assumed to be automatically attainable. Production facilities deteriorate when not used and rehabiliation can be slow. Furthermore, lead times between discoveries and production in established areas are several years and in new areas in hostile environments may be 10 years. However, one must expect that the national security aspect of indigenous petroleum will maintain a reasonable level of exploration both in the industrialized countries and in the non-OPEC developing countries, despite the suggested slow recovery in oil prices and, possibly therefore, slow investment in alternative sources.

In the longer term, in the late 1990s and early 2000s, some of the present OPEC members may be nearing the end of their petroleum resources at the production levels implied in this middle scenario, but not Iran, Iraq, or Kuwait, and certainly not Saudi Arabia. In the late 1990s, if not sooner, the weight of Saudi reserves could be expected to become the dominant force in pricing and production levels. The Saudis have demonstrated their appreciation of their strength and the need to use their strength wisely. Therefore, as long as the stability of the Kingdom remains, oil price stability can be maintained within the circumstances of the scenario suggested. Obviously the chances of stability would be enhanced if there was the international cooperation, which the Saudis and others would like.

Research Priorities For Developing Countries

The order of research priorities must be different in detail for every developing country because of the great variety in their resources and needs. However, I have attempted to indicate some of the uncertainties of our current knowledge and also one possible world petroleum environment in which all may have to operate. Study of individual countries will be required to determine how best each may operate successfully, but there seem to four general areas within which study would be of major benefit.

Increase in basic knowledge of indigenous energy resources

Geological survey techniques have developed greatly in the past 50 years, but they still cannot give answers sufficiently fast for the politicians. Nonetheless, hard and relatively slow research work is vital. A quick report by a consultant may be helpful but is no substitute for permanent local competence, which should be initiated or expanded, with outside help if needed. Vladimir Baum (UN 1982) noted that:

> Most developing countries recognize the need for solid institutional structures to deal with the complexities of energy policies.... In more than 80 countries national oil enterprises have been established.... A petroleum exploration policy can be devised only in the light of the specific circumstances in each individual country ..... and its own perception of its development priorities.

Therefore, although it is essential to detail the logical steps in exploration, and to study case histories, as were excellently handled in Part II of the 1981 UN meeting in the Hague on "Petroleum Exploration Strategies in Developing Countries," yet the individual circumstances of each country are paramount.

Identification of the optimum energy mix

All are agreed that petroleum must be linked with the overall energy needs and the national objectives. In most developing countries, however, there is little information and few trained personnel to gather data on the true needs of the country. Furthermore, there may be great, perhaps insuperable, political difficulties in identifying and presenting the true needs. For example, when Reza Shah Pahlevi tried to break the power of the nomadic tribes by settling them, he created a "modern" demand for farm tractors and diesel fuel, but the main effect was to reduce the agricultural resources and the flexibility of Iran, for only nomadic grazing could optimize the benefits of the semi-arid environment. In other words, the total environment must be considered in the identification of the optimum energy mix -- the human, natural, capital, and technological resources in the particular social, ecological, and political circumstances.

Identification of the optimum means to attain the optimum energy mix

There are dangers of fashionable trends that must be avoided. In the late 1950s, many developing countries considered a domestic oil refinery as an essential symbol of nationhood. In the 1980s, there is a danger that a petrochemical plant may have a similar appeal. An OPEC Secretariat paper to a seminar in Vienna in 1983 cautioned that production expansion of ethylene, despite an estimated doubling of demand in the Third World, should not be attempted except in those countries with "ample material endowment or potential power to penetrate world markets.... For the majority of developing nations, imports of basic or intermediate feedstocks will prove more economical." Although, perhaps, there is greater need in the petrochemical industry for vigorous and rigorous research before investment, yet the general point holds for all new projects. Unfortunately, the misplaced euphoria created by expectation of a limitless flow of petrodollars led to some status symbol projects in the later 1970s, which are "white elephants" in the early 1980s.

Economics of the total chain from supply to end use

Realistic appraisal of the economics of the total chain from supply through transportation and conversion to end use is not an easy task. Full allowance must be made for all costs when alternatives are being compared (Sierila 1983).

Conclusion

Finally and in sympathy with a major theme of this paper of viewing the total environment, there is need for determining how best to foster self-reliance. Fortunately, there seem to be signs of growing appreciation that blaming "the others," moaning against the present economic and financial structure, and begging for "cash," does not bring prosperity. The only answer is hard work.

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THE OIL CRISIS: ITS NATURE AND IMPLICATIONS FOR DEVELOPING COUNTRIES[1]

Peter R. Odell

Director, Rotterdam Centre
for International Energy Studies,
Erasmus University, Rotterdam,
The Netherlands

Introduction

The still near-concensus view of the future outlook for oil remains one of continuing real increases in prices (except for the very short term) and of an inevitable near-future peak in global oil production (again ignoring the temporary turn-down of the past 3 years as a result of cyclical influences on the market). The bases for this pessimistic view on the future of the world's major source of energy emerge, however, from the extrapolation of two sets of conditions that determined the history of the international oil industry before 1973:

- A high exponential growth in the use of oil as a sine qua non of the process of economic development; and
- The necessary geographical concentration of oil production in a limited number of countries and a growing dependence of the rest of the world on exports from these countries.

Global energy/oil models explicitly define, or implicitly assume, that these are, indeed, necessary conditions for the future of oil with a resultant near-future constraint on the ability of oil to meet the world's energy needs.

In this paper, however, I argue that the two sets of conditions were unique to the historic period 1948-73 so that their use in forecasting the future of oil is quite inappropriate. Post-1973 evidence, together with recognition of the reality of the 1948-73 conditions, indicate clearly the need for a reevaluation of medium- and longer-term oil supply/demand relationships. Work that we have done on these relationships suggest that the short-term weakness in the international market is likely to persist -- or to become even weaker -- over the next 30 years, as the general condition. Although this secular trend will, of course, be interrupted from time to time by abnormal and unpredictable political events and, in addition, there will be short-term variations in the price of oil for cyclical economic reasons.

Conditions that Determined the Pre-1973 Oil Market

Generally high economic growth rates in the pre-1973 period were accompanied by an even higher exponential growth rate in oil use. The apparent correlation between the two became, indeed, an article of faith. So much so that important elements that indicate that the relationship was little more than coincidental have been ignored or discounted.

First, the low and sharply falling real price of oil throughout the period incorporated careless and wasteful use components in the high increases in demand. These are being eliminated by high prices and are unlikely to return given a fundamentally changed perception of oil (energy) situation.

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1 This is a preliminary working paper and should not be quoted without express permission of the author.

Second, all types of economies in the world were then going through increasingly oil-intensive periods of development, e.g., the mass consumption of durable household goods, the mass-motorization phenomenon, and the accelerated suburbanization process in the industrialized countries, the use of rapidly increasing amounts of oil in the centrally planned economies, as a consequence of their industrialization in regions where the use of coal was not practicable; and the Third World's near exclusive use of oil in the energy-intensive, initial industrialization period.

Third, in the industrialized world, accounting for most of the world's total use of energy, oil was being substituted for coal in every country as the result of contrasting labour cost conditions in both production and use, and of contrasting environmental considerations.

This extraordinary temporal coincidence of factors that pushed up the use of oil so rapidly over the 25 years for 1948-73 can never occur again.

On the supply side, the intense geographical concentration of production emerged from several factors.

- British/U.S. political control over the Gulf region and over a number of other countries created conditions in which there could be an unrestricted exploitation of the oil resources discovered in these regions.

- The highly prolific and low-cost nature of the resources discovered enabled production in these countries, the Organization of Petroleum Exporting Countries (OPEC), to grow rapidly enough to more than satisfy even the 7.5% per year growth in demand so that the search for resources elsewhere was largely abandoned, while the exploitation of other, already known resources was undermined.

- Production from the OPEC countries was, moreover, increased rapidly in spite of the declining real price of oil in the market place -- largely as a result of the incidence of intense competition in the international oil industry from 1958 to 1970. In these circumtances, the companies could only remain profitable by concentrating their upstream activities in the proven low-cost oil countries and they were thus obliged to ignore alternative options for producing oil.

Overall, it was these specific politico-economic conditions, rather than inherent resource-base considerations, that produced the highly skewed global geographical distribution of oil reserves and production capacity over the more-than 20 years leading up to the early 1970s.

This powerful melange of both oil-demand and oil-supply factors was the prime cause of the revolution in the world oil system in the early 1970s: although its timing was determined by the almost equally extraordinary set of political events that affected the main actors in the world oil industry after 1968. These consisted of the reestablishment of cooperation between most of the western world's oil companies to achieve orderly markets; the belated recognition by the companies that OPEC could be used as the reason why the price of oil had to increase; the subsequent joint interests of the companies and OPEC in moving oil prices up after 1970, and the even more powerful impact of the Arab-Israeli war in 1973 in this respect; the upstaging of the companies by OPEC's members in 1973-75 when the latter decided the companies were irrelevant to supply and pricing questions; and, finally, an event that not only saved the exporting countries from the miscalculation they had made of their strength, but also enabled them to double prices yet again -- that is, the revolution in Iran.

As a result of all these politico-economic changes, the hitherto plentiful supply of oil, albeit from a geographically limited part of the world's ultimate oil base, was converted over the short term to one of scarcity -- arising from restraints on production and development by small numbers of suppliers. Oil production elsewhere could not be expanded quickly. Even in the USA, the industry had been too weakened by international competition, and elsewhere there were no short-term supply prospects of any significance. This short-term absence of alternative supplies was critical for prices given the high exponential growth in oil use, the expectation that this necessarily had to continue, and the unwillingness of the industrialized countries to curb demand by direct controls.

The "scarcity" that emerged in the 1970s was, thus a political-cum-institutional problem. It has, however, ever since then generally been interpreted, or rather misinterpreted, as an unchangeable, or even an uncontrollable, development in the evolution of the global oil industry. This, in turn, has generated a near-unbelievable decline in confidence among oil companies that, until 1973, were absolutely certain of their abilities to provide the world with whatever volumes of oil (and gas) it proved to need for the forseeable future.

Consequences for Oil (and Energy) Forecasting

As a result of the powerful impact of the pre-1973 demand/supply conditions and relationships, and given the misinterpretation of the real nature of the post-1973 oil situation, oil and energy forecasting has since developed under the influence of basically false premises -- in respect of demand, supply, and price.

Expectations on the demand side have been too high. This is partly because of an underestimate of the oil shock (and other factors) on the prospects for economic growth, but the failure to recognize the very special demand conditions of the 1958-73 period for energy use in general, and for oil use in particular, has been of more importance. With conditions of radical, even revolutionary, change, there was an inexplicable unwillingness to consider both the price and income elasticities of demand and the significance of the substitution of the use of oil by the use of other sorts of energy. Markedly lower use rates, compared with the pre-1973 period were, and indeed to some extent still are, seen as the aberration, rather than as the return to the normality of long-term energy growth rates from which the experience of 1948-73 was the essential divergence. In the long term, a 5% per year energy growth rate was a very high, rather a normal rate that, hitherto, had averaged 2.2% per year (Marchetti and Nikicenovic 1979).

Moreover, in the context of expanding availabilities of energy sources that can substitute the hitherto dominant oil component in the global energy picture, the use of oil must now grow at a rate lower than that for energy overall for at least the rest of the century.

Expectations for the medium to longer term (politically nonconstrained) development of the oil-supply potential have, by contrast, become too low. When the companies still had confidence in their own abilities to control the development of the world's oil resources, they did not hesitate to prognosticate a long-term future for the industry which, by definition, required a resource base of at least 5000 X 10^9 barrels -- as shown in Fig. 1. Their withdrawal from this view coincided with their declining power in the system. This produced a change of mind on their part on the global availability of oil reflecting their idea that if they were not encouraged, or at least allowed, to find and prove the world's oil then there were no alternative organizational or institutional arrangements that were capable of taking over the upstream activities. Thus, they argued, much of the world's oil must remain unexploited. Hence, instead of the minimum 5000 x 10^9 barrels of expected ultimately useable oil, the understandable, but nevertheless the nonsubstantiated, views of the oil companies now wrote down the total oil potential to 2000 x 10^9 barrels, which in the context of a demand growth rate of 7.5% per year until 1985 and at 5% per year as long as possible thereafter produced the view of the future of oil illustrated in Fig. 2.

The increased prices for oil since 1973 have been thought to give the classical market signal of resource scarcity, with repeated references to the "market price" for oil carrying the inference of competitive market clearing prices to which all other energy prices must "wisely" be adjusted. But post-1973 oil prices have been no such thing: they have represented a virulent new strain of oligopolistic pricing -- in the context of short-term supply constraints by producers exercising a temporary control over global output levels, and with the effects exacerbated by inappropriate user responses motivated by the industrialized countries' interpretations that oil demand was inherently price-inelastic. The levels to which oil prices rose by 1980 under these circumstances thus provide a singularly inappropriate base from which to speculate on future price developments -- and on potential supply and demand developments. A reevaluation in respect of all three components is clearly necessary.

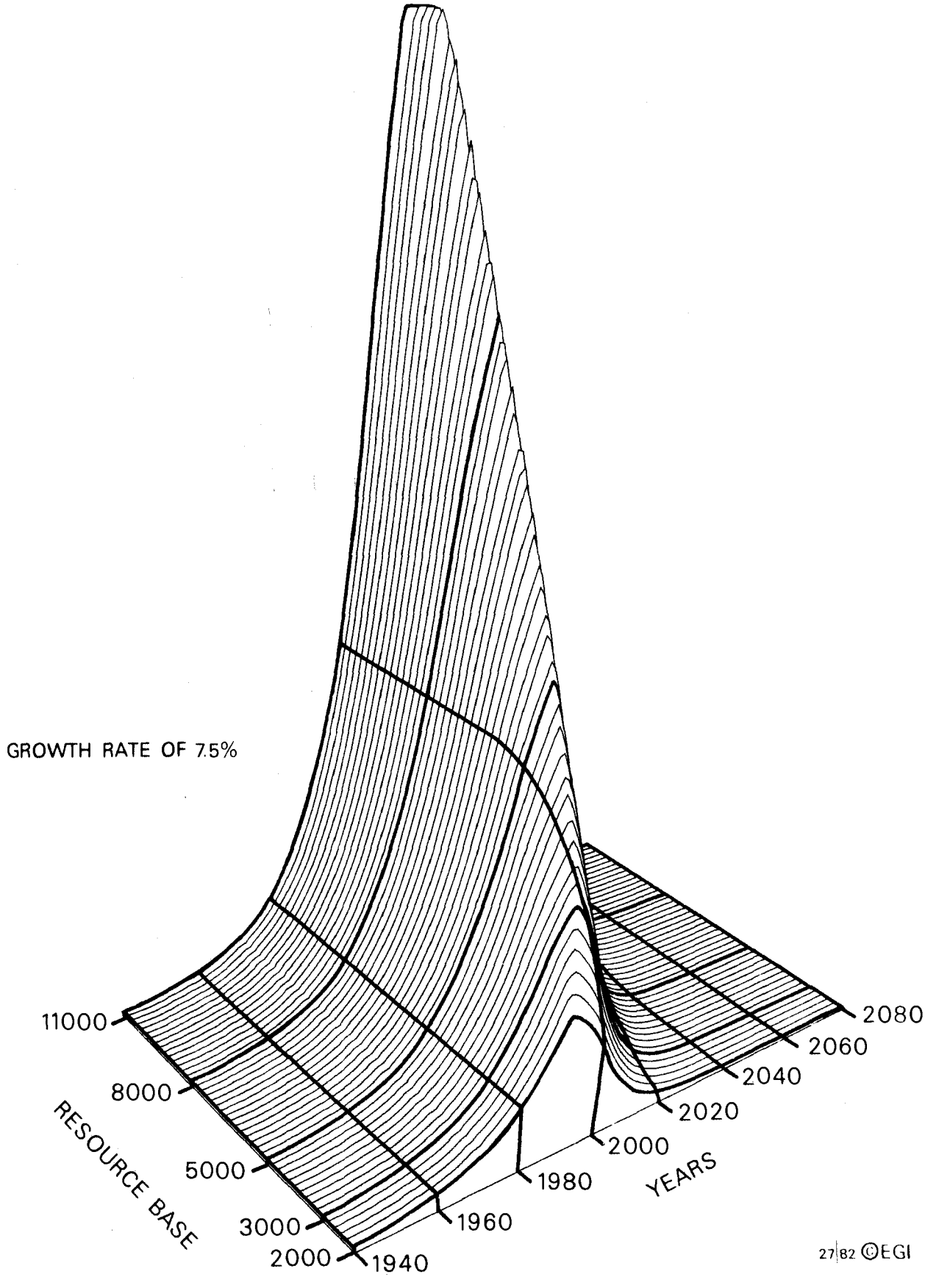

Fig. 1. Relationship of world oil demand to resource base for 1940-2080.

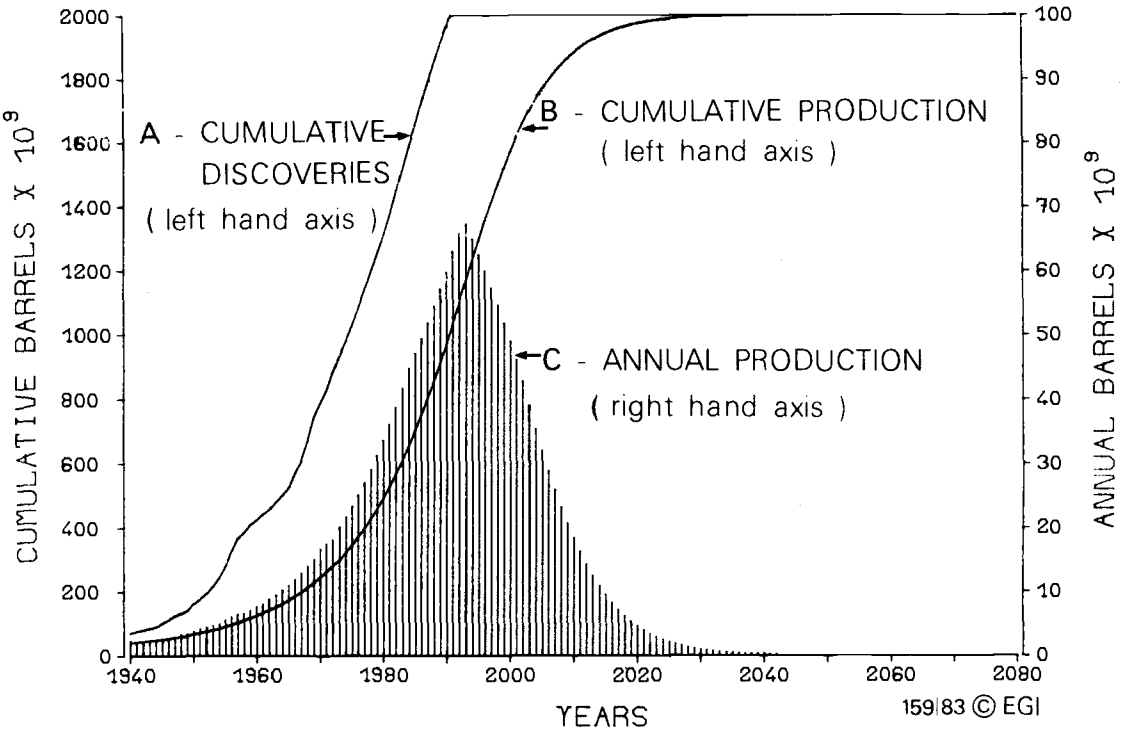

Fig. 2. Cumulative discoveries and production of oil over time (1940-1980) and annual production (1940-2050).

Medium-term outlook for price behaviour

The long-run supply price (LRSP) of oil in 1970 -- and the shape of the curve over the previous 20 years was derived by Adelman (1972) before the oil-price shock and has recently been confirmed at a level of US $2 per barrel (in 1973 dollars) in work by Fayat (1983). This curve is shown in Fig. 3 but with prices converted to 1980 dollars.

The evolution of the LRSP is a function of the future rate at which the use of oil cumulates, as it is this which determines the timing of the need to move to the production of successively higher cost oil resources. An indication of the changing shape of the future LRSP curve is also given in Fig. 3 with the rate of growth in oil use ranging from a high of 7.5% per year from 1970 (the expectation at the time of Adelman's analysis) down to 0% beginning in 1983 (a rate which should be compared with the -0.59% per year average decline in oil use over the last 10 years).

From the base-year of 1980, a curve has been drawn to represent the evolution of the LRSP in a situation of oil use increasing exponentially at 2.5% per year. We have argued (Odell and Rosing 1983: 172-182) that the annual average rate of increase in oil use will not exceed this level. Our views in this respect are basically a function of the arguments set out in the first two sections of this paper. It is a rate of increase that is much higher than the average for the last 10 years (-0.59% per year), and higher than the oil industry's next 10-year view of the market potential. We do not think, therefore, that there will now be much dispute over our choice of a 2.5% per year growth rate as one that is very unlikely to be exceeded.

The rise in the LRSP curve from 1983 shown for this rate of growth in use under the impact of oil use before 1983 is relatively gentle until well into the 21st century. The justification for this emerges from a continued availability of large volumes (over 600 x 10^9 barrels) of oil that is profitable to produce at $4 per barrel or less (in 1980 dollars). The derivation of this is shown in Table 1 and relates essentially to the known proven reserves of 635 x 10^9 barrels in 1973 and which reserves were, by definition, economically recoverable at the then current oil price, i.e., $2 per barrel (or about $4 per barrel in 1980 dollars).

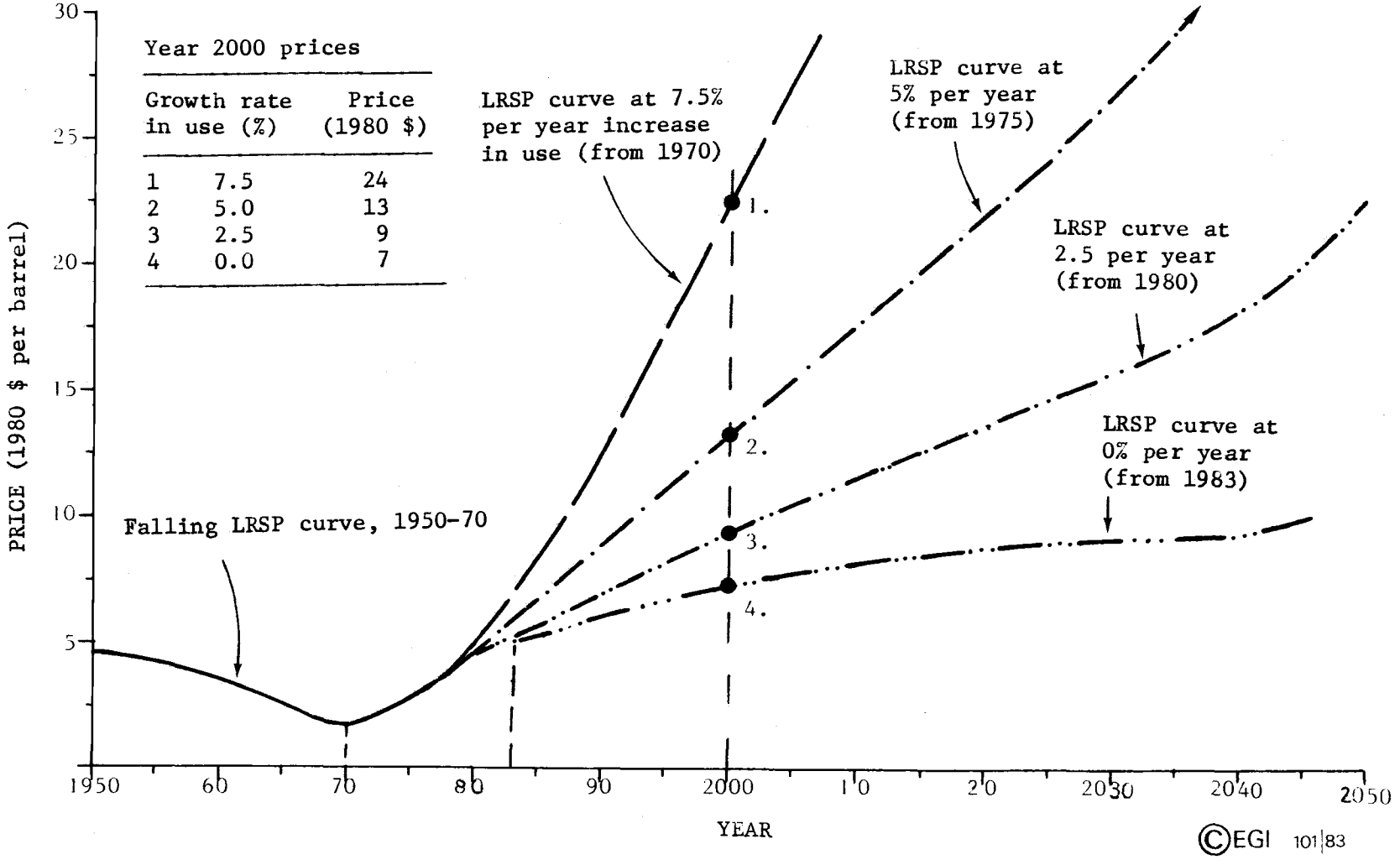

Fig. 3. LRSP curve at various rates of growth in use.

Table 1. Deriving the availability of low-cost oil in 1983[a]

	Oil amounts (x 10^9 barrels)		
	Total	Low-cost	Higher-cost
Remaining Proven Reserves, 1973		635	
Oil use, 1974-82	190		
Higher-cost oil			40
Net use of low-cost oil		150	
Remaining low-cost 1973 Proven Reserves, 1983		485	
Additional reserves proven in 1974-82	245		
Higher-cost reserves			120
Net additional low-cost reserves		125	
Total remaining low-cost reserves at beginning of 1983		610	

[a] Oil that is economic to produce with a price of $4 per barrel or less in 1980 dollars.

Table 2. Future use prospects for currently available low-cost reserves[a]

1	World oil use, 1982	about 19.5 x 10^9 barrels
2	Low-cost oil reserves to production (R/P) ratio	31.3 years
3	Effective R/P ratio with a -0.59% per year continued decline in oil use	35.3 years
4	R/P ratio assuming an average 2.5% per year growth in oil use	about 23 years
5	Assume: a. a 2.5% per year oil use growth b. that 75% of world oil demand will be supplied by low-cost known reserves c. a depletion curve restraint (viz., a minimum R/P ratio of 11 years) on the use of low-cost oil Then: Production of low-cost oil will peak in 2001	

[a] 610 x 10^9 barrels, as derived in Table 1.

Table 2 shows how, under various specified conditions, the low-cost oil could keep global oil production moving ahead. The "simple" and the "effective" ratios of reserves to production are indicative of time spans to exhaustion, and are thus purely conceptual. Of more importance is the indication of the period -- that is to after the year 2000 -- during which this low-cost oil could sustain a growth rate of 2.5% per year, with but a modest amount of help from the use of some higher-cost oil in conditions or countries, or both, in which such theoretically uneconomic oil can be marketed. This would be in conditions in which (as currently) the price of oil in the market is above the LRSP, and in countries where protection is given to higher cost indigenous production -- for strategic or economic policy reasons (as, for example, in the USA and the USSR and, say, India or Brazil in the Third World).

The LRSP curve that relates to the 2.5% per year average rate of growth in oil use is shown as moving slowly up from its present (1983) level of $5 per barrel for the rest of the century -- as such an upward trend is required so that the propensity to invest in increasing cost oil can be maintained. Thus, after the year 2001, when the decline curve for the output of currently known low-cost oil sets in, the price at $10 per barrel (in 1980 dollars) is high enough to ensure a smooth uptake of higher cost oil -- as and when required.

If we take 2010 as the end of the medium-term future, then, the volume of higher-cost oil that would have had to be used by then remains modest -- about 200×10^9 barrels. There is a near zero likelihood that this will not be discovered by 2010 given, first, the volume that was discovered in 1974-82 (120×10^9 barrels) some of which will not be used in the interim period as it will not be competitive with low-cost oil; and, second, the potential availability of large additional volumes of oil from environments with which the industry is already familiar (e.g., the continental shelves in tropical and temperate latitudes), and through technologies with which it is used to working (e.g., enhanced oil recovery from known fields).

In other words, for the medium term, supply/demand relationships indicate an LRSP for oil that always remains much lower than the price of $28.50 in the reference year of 1980 and well below the level to which the price has now fallen -- about $24.50 in 1980 dollars. There are a range of possibilities open on the levels of price in the years 1990, 2000, and 2010. For 1990, we put the range at 67-94% of the 1980 level ($19.10-26.80 per barrel); for 2000, from 56-81% of the 1980 price ($16.00-23.00); and for 2010, from 45-75% of the 1980 level ($12.80-21.40). This steadily falling price over the 1980-2010 period reflects our view that a price collapse to the LRSP will be averted by means of convergent OPEC and Organization for Economic Cooperation and Development (OECD) oil supply and pricing policies. The range of price levels by 1990 and in succeeding years will thus be a function of the timing and the intensity of the negotiations out of which the convergent policies will emerge. This is demonstrated graphically in Fig. 4.

On the Longer-term Prospects in Theory

There is some danger that there will be no real longer-term prospects for oil because of a perception of the medium-term outlook that is very different from the one described above, and the consequential possibilities of policies that, as a result, will serve to kill the industry. Continued too-high prices for oil, and further loss of confidence by the oil industry in its ability to cope with a changing global political environment, coupled with a failure to secure the establishment of institutions that are capable of keeping the oil industry expanding (a highly relevant issue after 3 consecutive years of decline) could well lead to too little use of oil in the future.

In this respect, it is worth noting that five recent comparable models of world oil (forecasting up to 2020) all show the industry peaking at or before the year 2000, at levels of output little higher than that of the historic 1979 peak. Furthermore, they all imply a total cumulative world oil use by 2020 of about $1450\text{-}1550 \times 10^9$ barrels -- as demonstrated in Table 3. The world oil industry would, moreover, by then according to the five models, be so long past its peak that even the lowest estimate of the world's conventional oil resources would still mean an availability of enough oil for a decline period extending beyond 2080. Nor do the models indicate any use of "backstop" oil (that is

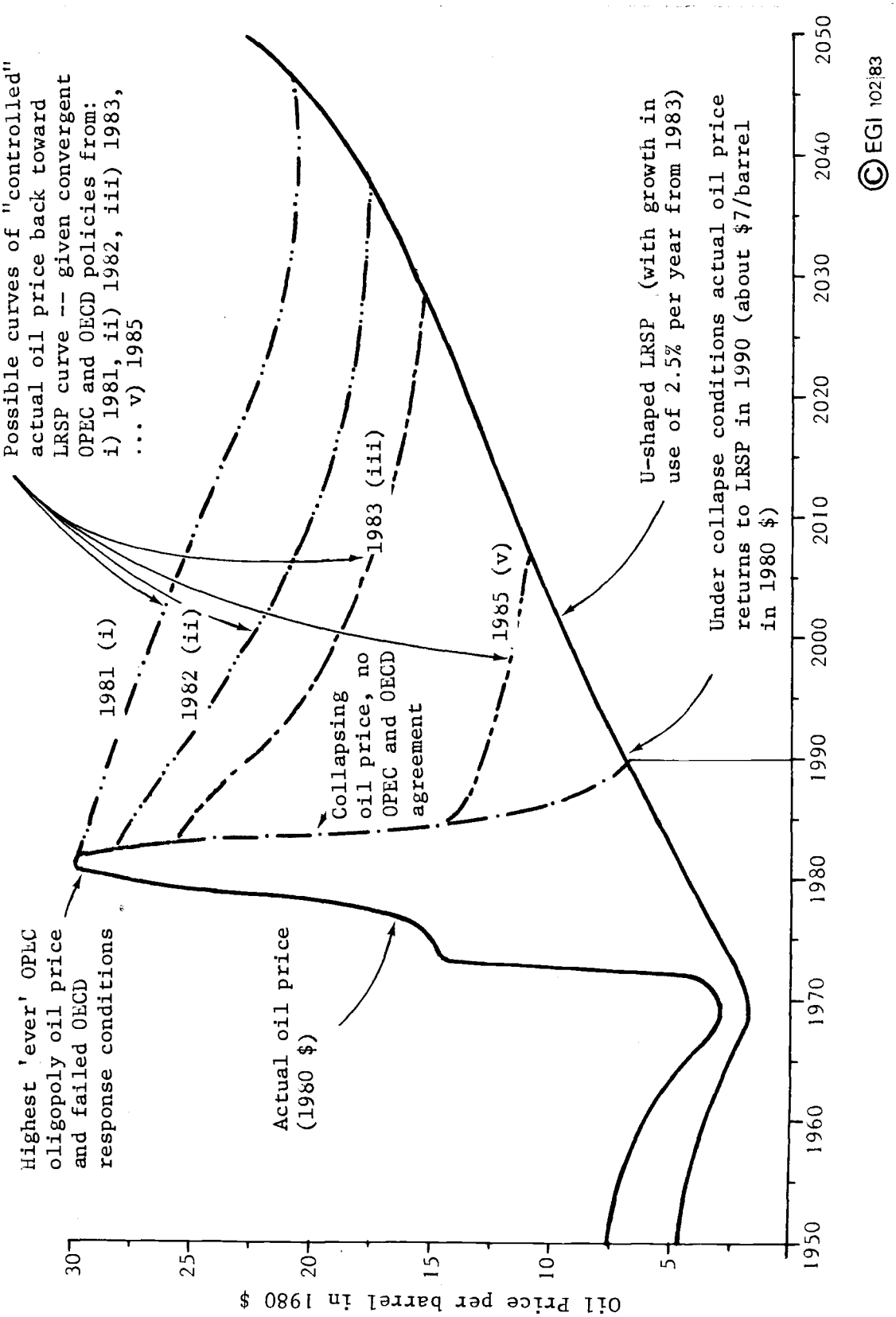

Fig. 4. Oil prices, 1950-2050.

Table 3. Five models of global oil use, 1980-2020

i -- Calculation of arithmetic mean of non-Communist world oil production ($\times 10^9$ barrels/day)

Year	Model					Arithmetic mean	Coefficient of variation
	A	B	C	D	E		
1980	40.6	51.4	47.7	51.8	48.5	48.0	0.084
1990	52.1	53.5	46.8	49.8	55.7	51.6	0.027
2000	64.9	53.2	47.7	48.6	52.0	53.3	0.052
2010	53.3	50.0	38.3	44.1	49.5	47.0	0.050
2020	47.8	44.4	31.7	37.1	48.4	41.9	0.089

ii -- Adjustment of the models to a total world basis ($\times 10^9$ barrels/day)

Year	Non-Communist[a]		Communist[b]		Total World	
	Production	Annual average growth (%)	Production	Annual average growth (%)	Production	Annual average growth (%)
1980	48.0		14.9		62.9	
1990	51.6	+0.73	20.9	+3.44	72.5	+1.43
2000	53.3	+0.32	25.2	+1.89	78.5	+0.80
2010	47.0	-1.25	27.2	+0.77	74.2	-0.56
2020	41.9	-1.14	30.5	+1.15	72.4	-0.02

iii -- Implied cumulative global oil use to 2020 in world oil models ($\times 10^9$ barrels)

Model	Model oil use 1980-2020 (non-Communist)	Communist oil use 1980-2020	World pre-1980	Total world to 2020
A	796.5	357.7	427.8	1582.0
B	764.1	357.7	427.8	1549.6
C	643.1	357.7	427.8	1428.6
D	698.2	357.7	427.8	1483.7
E	767.9	357.7	427.8	1553.4
Average[c]	765.4	357.7	427.8	1550.9

Source: World oil: Summary report. Stanford University, EMF Report 6, tables A5-A9, 1982.

Notes: **Model A** is Salant/ICF of the U.S. Federal Trade Commission; **Model B** is WOIL of the U.S. Department of Energy; **Model C** is Kennedy/Nehring of the University of Texas/Rand Corporation; **Model D** is OILTANK of the Chr. Michelsen Institute (Norway); and **Model E** is OILMAR of the Energy and Power Subcommittee of the U.S. House of Representatives.

[a] From Table 3(i).
[b] Author's estimate.
[c] Arithmetic mean of the five models as calculated in Table 3(i).

unconventional oil and oil from coal), even though the prices they predicate are far above the level at which the backstop oil would become economically attractive to produce. The industry, they seem to suggest, will, in other words, have been so weakened by contemporary difficulties as to render it incapable of ever utilizing the world's oil resources.

The key issue for ensuring the survival of the oil industry is downward movement in prices whereby oil is made sufficiently attractive to use, compared with inherently higher cost, but much lower-priced, alternatives (such as coal, nuclear power, and most renewable energy sources). In this respect, long-term oil models that, as a result of illogical constrained supply and unjustified high exponential growth in oil-use assumptions, show real oil prices rising to 153.5% of their 1980 level (Beltramo and Manne 1983), or about 175-180% of present prices, are counter-productive in their effects -- not only for the future of the world oil industry as such, but also for the western world's economic growth prospects overall. Such prospects are worsened as a result of the inflationary consequences of continued oil-price increases, and the inevitable decisions by governments to devote too many scarce resources of capital, management, and other expertise to investment in higher-cost alternative-energy developments.

Given the, by now, quite strongly institutionalized barrier to a realistic attitude to the future of oil[2], it is highly unlikely that the probabilities of future growth rates for oil will be any greater than those shown in Fig. 5. For example, there is only a $\pm$ 10% probability that the growth rate will be 2.62% per annum or higher; only a 50% probability that it will reach 1.5% per annum and a 10% probability that it will be only 0.5% or less. Nevertheless, for purposes of setting out future oil-use/resource-availability relationships let us assume that the growth rate in use can be pushed back up to an average from 1980 of 2.62% per year. In the context of this level of future use of oil, there is really little need to get heavily involved in the contentious debate over the prospective volumes of ultimately recoverable conventional oil (see for example, Dunnington 1982; Odell and Rosing 1982).

We may thus ignore, on the one hand, the high estimate of 11 000 x 10^9 barrels of such oil made by Soviet Academician Styrikovich (1977) and described by him at the time as a "cautious estimate"; and similarly, on the other hand, the few ultrapessimists in the oil industry with their estimates of ultimate conventional oil reserves of no more than 2000 x 10^9 barrels. Note, incidentally, that such estimates imply that there are only another 400 x 10^9 barrels of oil to be found in the world -- after allowing for use, plus currently Proven Reserves, and the appreciation of those Proven Reserves. This is an impossibly low figure, given the large areas of the world that remain to be explored for oil. A widely accepted minimum figure for ultimately recoverable conventional oil, with some degree of enhanced recovery is (including oil used to date) 3000 x 10^9 barrels. Against a growth rate of 2.6% per year, and an upper limit of 50 x 10^9 barrels on the annual rate of additions to reserves (emerging from both new discoveries and the appreciation of previously discovered oil reserves), this produces the depletion curve shown in Fig. 6 with the prospects for growth in conventional oil production through until 2017.

But this, of course, covers only part of the world's potential ultimate oil reserves, as there is still also oil from unconventional habitats, as well as heavy conventional oil (but still excluding the potential for making oil from coal) to be taken into account. These resources (the development of some of which is already under way -- albeit prematurely, given the higher costs involved) are usually disparagingly referred to as "backstop" or "reserve" oil, and so inappropriately categorized when judged from an economic standpoint. Instead, one needs to approach their utility simply as an additional set of oil reserves that are quite capable of being converted into the oil products that are demanded by consumers. Oil users are, indeed, quite indifferent to the origin of the standardized oil products they need in terms of the oil's original habitat, or its pattern of physical occurence -- in the same way that coal users are indifferent to the deep-mined or open-cast origin of a supply of coal with specific quality characteristics.

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[2] By no means the least of the causes of this development was, unhappily, the report of the Energy Systems Program Group of IIASA (1981) in which the prospects for oil were inadequately considered and conclusions of a doubtful validity reached.

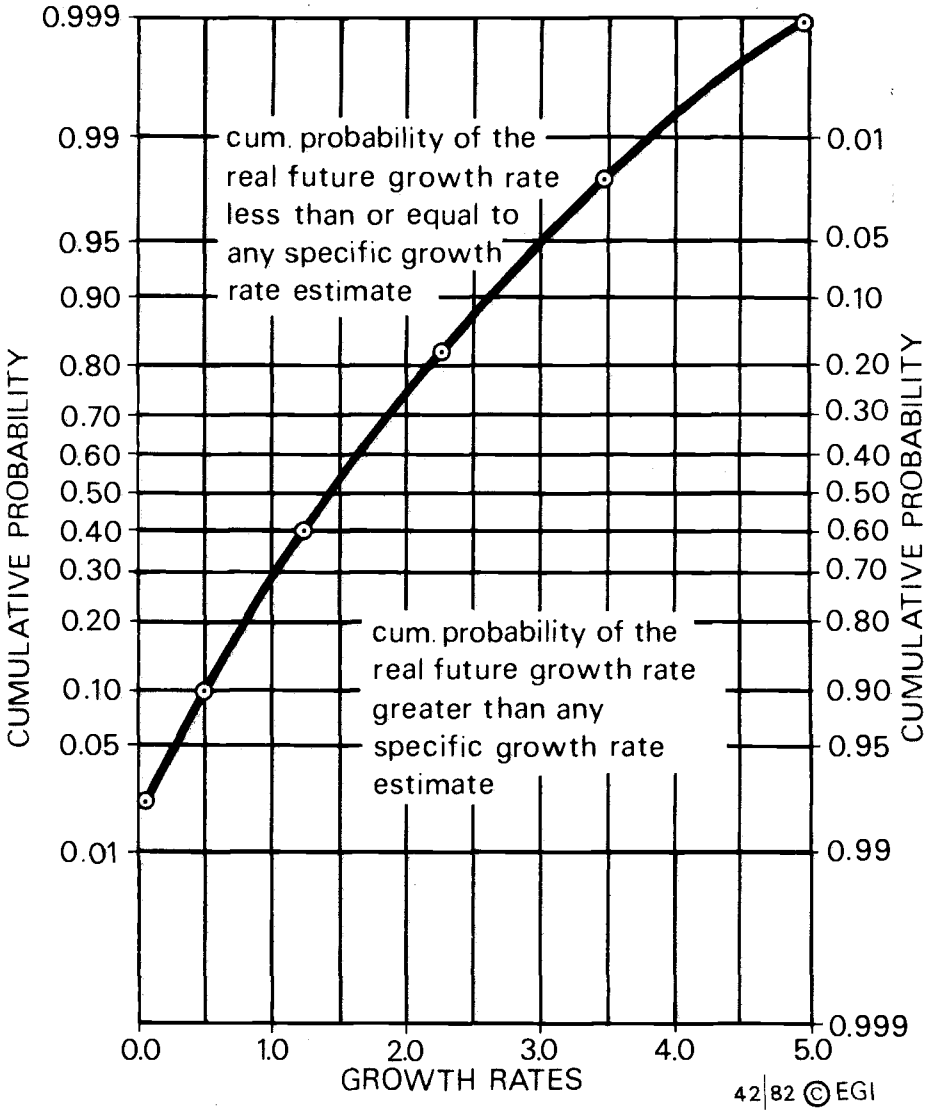

Fig. 5. Cumulative probabilities of real future growth rates greater or less than/equal to any specific growth rate estimate.

Thus, in economic terms, we can assume that the resources of conventional and unconventional oil provide a continuum of oil products' supply to be marketed in the context of a rising LRSP (see Fig. 4). There is no doubt that the ultimately recoverable resources of unconventional oil total a minimum of 2000 x 10^9 -- given present technology and the present state of knowledge of the world's relevant geology (Meyer and Fulton 1982). With more geological exploration and evaluation, and with developing production and treatment technology, the world's resources of unconventional oil would become a multiple of this minimum figure.

Let us, however, assume an ultimate availability of 2000 x 10^9 barrels, and then further assume that all unconventional oil is higher cost than the most expensive recoverable conventional oil so that the former only enters the market as the latter becomes unable to sustain a specific growth rate in oil use. If we again take the 2.62% per year growth rate and plot this against a total oil-resource availability of 5000 x 10^9 barrels (= 3000 x 10^9 barrels of conventional oil plus 2000 x 10^9 barrels of unconventional), then the curve of depletion is as shown in Fig. 7. The industry now reaches its peak production in the mid-2030s at roughly 3.3 times its present size.

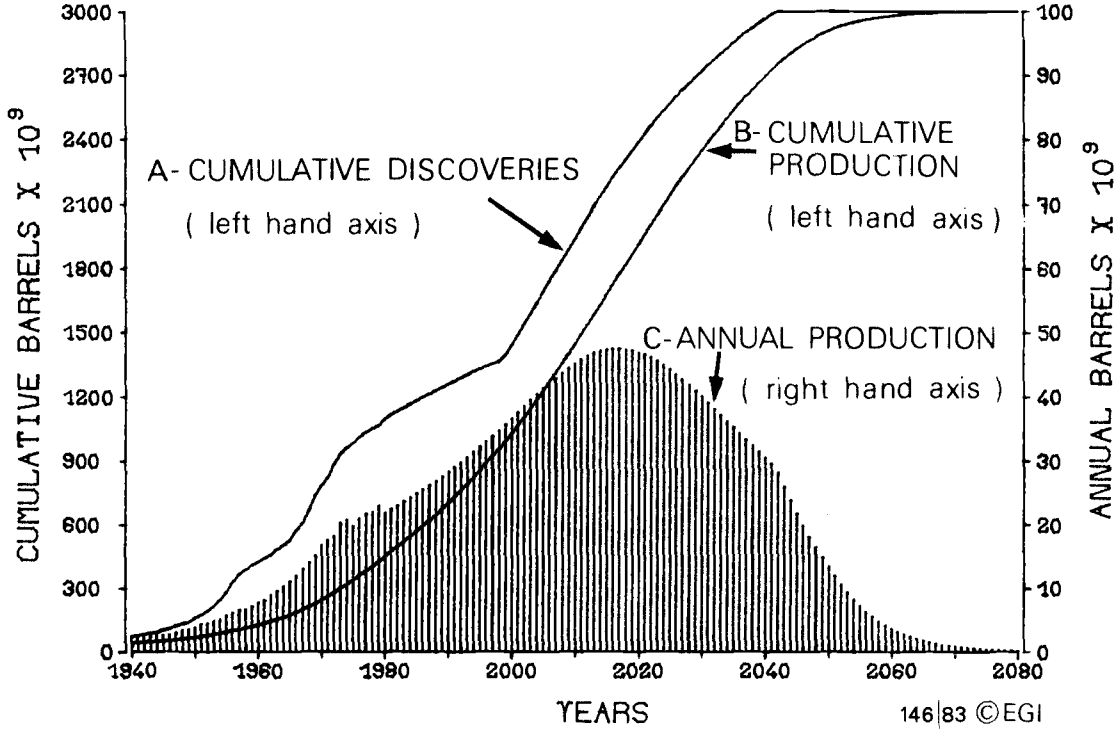

Fig. 6. Cumulative discoveries and production over time, and annual production, 1940-2080, based on a total resource availability of 3000 x 10^9 barrels, and a rate of increase in use of 2.6% per year.

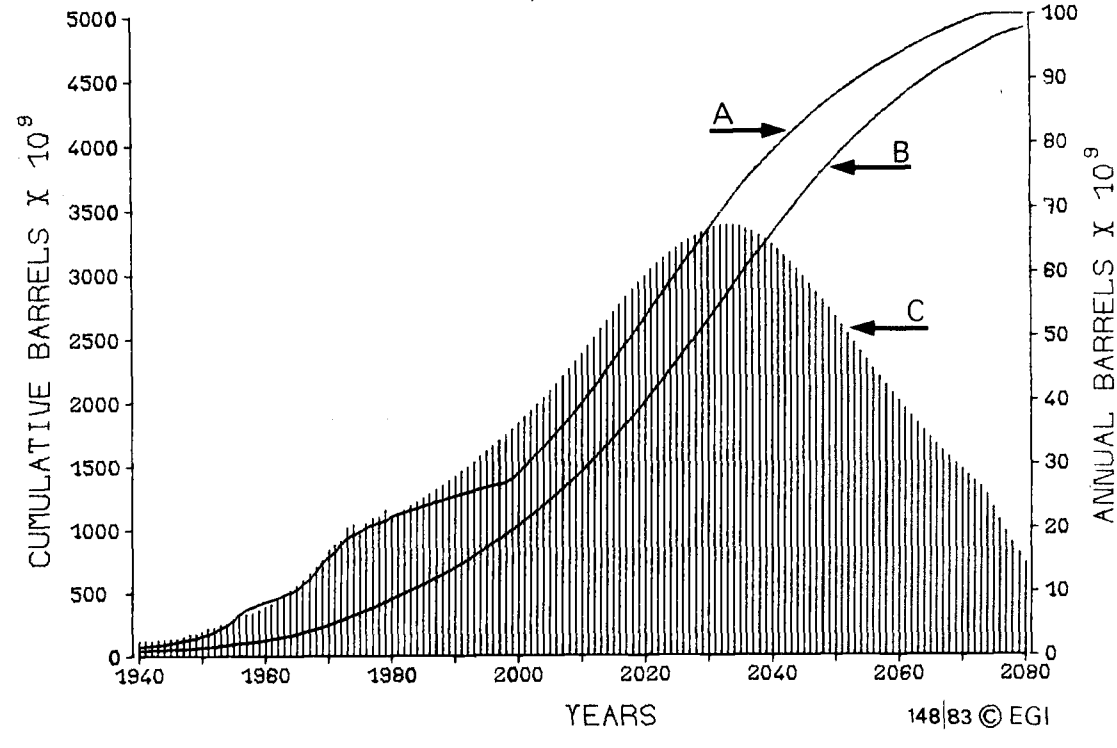

Fig. 7. Cumulative discoveries (A, left axis) and production (B, left axis) over time, and annual production, 1940-2080, based on a total resource availability of 5000 x 10^9 barrels and a rate of increase in use of 2.6% per year.

The output relationship between conventional and unconventional oil (on the assumptions as specified) within the total is shown in Fig. 8; and Fig. 9 shows separately the required contribution of unconventional oil to the developing supply curve -- its contribution starts in 2012 and the production of unconventional oil peaks in about 2060. In other words, the use of unconventional oil is essentially a 21st century industry, so that recently announced delays in the exploitation of, for example, Orinoco basin heavy oil, oil from the Athabasca tar-sands, and oil from shales in the USA recognize in essence the premature moves that were made toward the production of these higher-cost oil resources under conditions of the false -- or mistakenly interpreted -- oil-price signals of the 1970s.

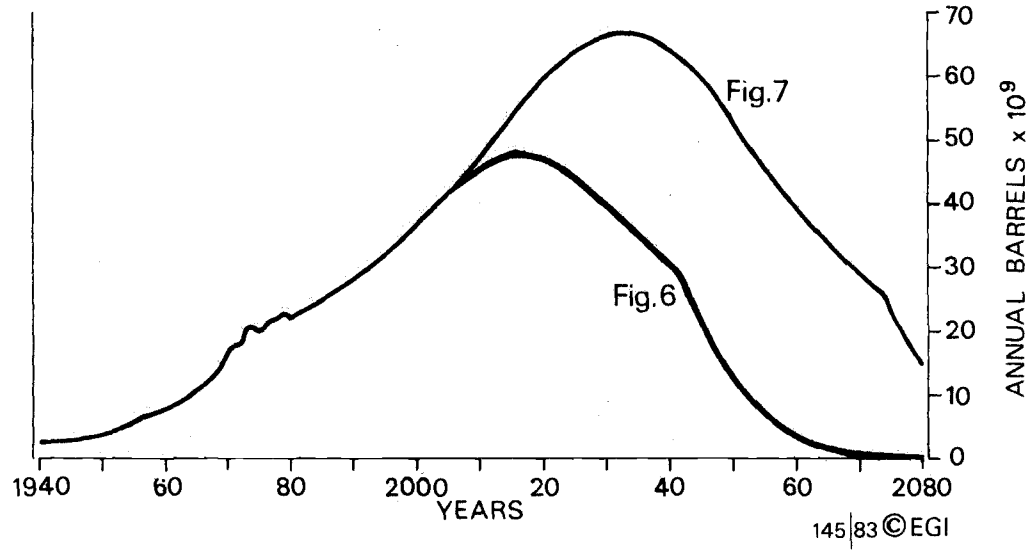

Fig. 8. Annual production 1940-2080 based on total resource availabilities of 3000 x 10^9 barrels (Fig. 6) and 5000 x 10^9 (Fig. 7) and a rate of increase in use of 2.6% per year.

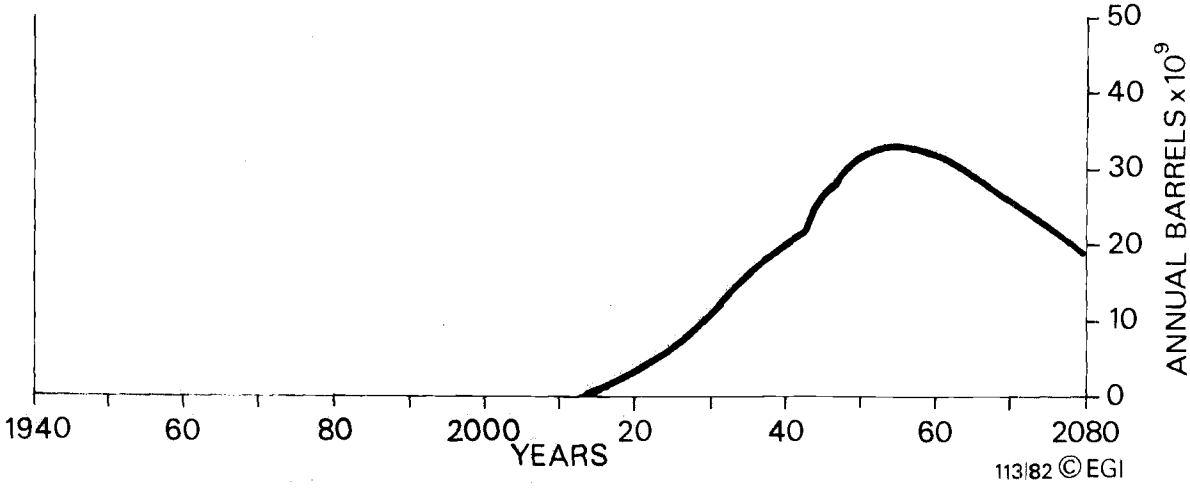

Fig. 9. Required contribution of unconventional oil to fill the gap between total resource availabilities of 3000 and 5000 x 10^9 barrels.

On the Longer-term Prospects in Practice

The aggregate of countries' and of producers'/consumers' decision will produce a global evolution of the oil industry different from that of the

mechanistic approach as described in the previous section. The interests of so many powerful nations and other groups are now so tied up with present oil prices that prices seem almost certain to be higher in the short to medium term than they need be, given the resources/use relationships that have been established as theoretically possible in the preceding section. Morover, in the more-difficult-than-necessary economic world that will emerge from the misinterpretation of the oil prospects, financial and other resources will unwisely be devoted to the production and protection of some high-cost alternative energies -- and also high-cost conventional oil, unconventional oil, or oil from coal -- according to the local or national circumstances. More generally, rates of economic growth will be kept down in an atmosphere of protectionism and beggar-thy-neighbour attitudes.

The overall result will, on the one hand, be an enhancement of the supply/potential supply of energy in general, and of oil in particular and, on the other hand, a limitation on the rate of use of oil (in the context of a reduced energy-use rate): the inevitable disequilibrium between supply and demand will be controlled by interventionism in the market for as long as the costs are not perceived as being too excessive, and this will be justified politically, as now, on the grounds of oil being an inherently scarce commodity. The outcome will not be comfortable, but it will probably be workable, providing Third World debt can be kept under control and providing the development needs of the Third World can continue to be ignored.

In this context, more rather than less oil resources will be sought and found (as a result of high prices and of nationalistic attitudes toward investment in the industry over the long term); and less rather than more oil will be used (also as a result of high prices, of government policies that deliberately seek to minimize oil use, and of consumers' perception of oil as the energy of last resort). Thus a long-term global oil resources/use relationship that would appear more realistic than the combination of 5000 x 10^9 barrels with 2.6% per year examined in the previous section is one in which the resource base side is moderately increased (to 5800 x 10^9 barrels) and the rate of use element reduced to just under 1.9% per year -- the input values in a simulation that we have described elsewhere as the joint 50% probability value of parameter values (Odell and Rosing 1982: 183-187). The result is illustrated in Fig. 10 in which

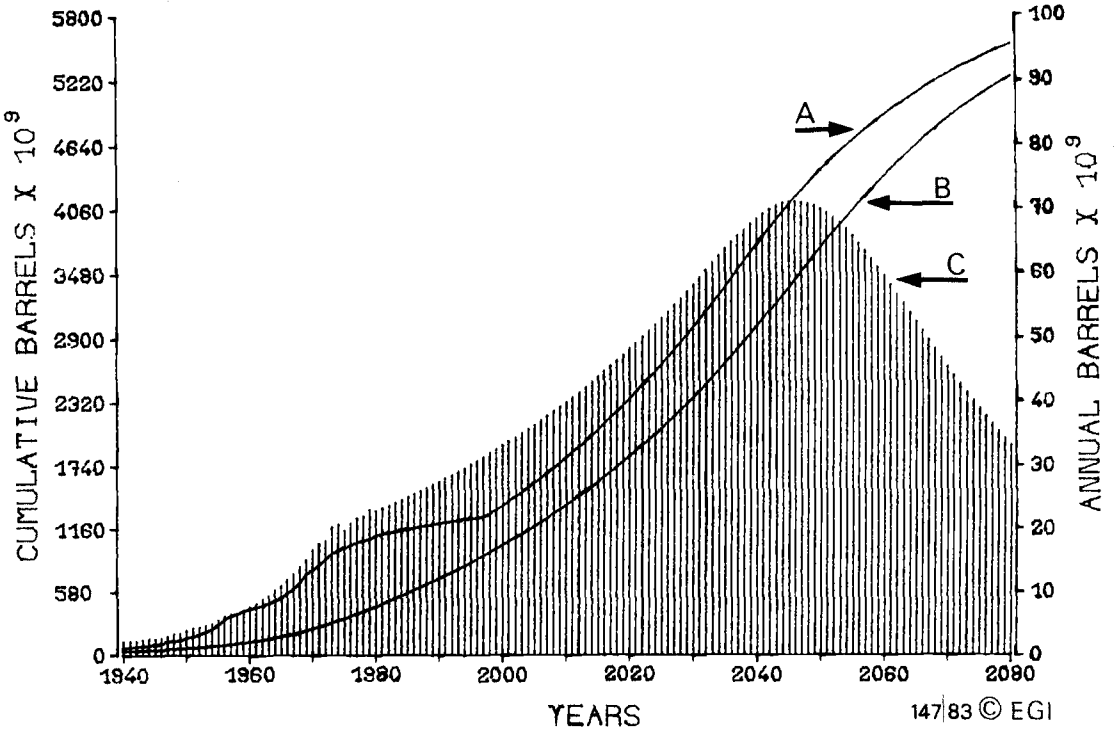

Fig. 10. Cumulative discoveries (A, left axis) and production (B, left axis) over time, and annual production, 1940-2080, based on a total resource availability of 5800 x 10^9 barrels and a rate of increase in use of 1.9% per year.

the simulation also includes a maximum annual addition to reserves constraint (of just under 75 x 10^9 barrels). The world oil industry now takes longer to grow to roughly the same size as with the combination of 5000 x 10^9 with 2.6% per year values. The peak of oil production is reached in 2046-47 at about 3.5 times its 1980 size: and in 2080, even after over 30 years of postpeak decline, the industry is still 1.5 times its 1980 size and at that date about 20% of the world's ultimate resources of oil will remain to be used. In essence, the potential growth phase of the global oil industry is still a near three-generation phenomenon. Even after peak production has been achieved, moreover, there are unlikely to be constraints on the availability of oil for present nonsubstitutable uses for at least another generation (on the assumption that such uses rise to between 45 and 50% of total oil use).

Reduced Price Oil and the Global Energy Economy

With relatively modest views on world oil resources -- conventional and nonconventional (so modest, indeed, that they are little higher than the minimum near-certain ultimate availaility of oil) -- and a rate of increase in use that now needs to average over 2.0% per year (to make up for the decline in use since 1979), the global oil industry still has at least a 60-year growth potential. In the meantime, as shown earlier in this paper, there are only political or institutional factors or both, that need put the market price of oil (in real terms) above the 1980 average level of about $28.50 (for Saudi Arabian marker crude) in the medium-term future (until 2010). Thereafter, as shown in Fig. 4, the LRSP curve will start to move up more sharply (to enable higher-cost conventional oil to be recovered and to generate interest in the recovery of unconventional oil, which we have hypothesized will need to enter the supply pattern in the second decade of the 21st century). By the time the oil industry is approaching its peak in the late 2040s, the competitive price of oil may well be reapproaching its historic peak level -- after almost 70 years of oil at a lower real price than in 1980.

With a growth rate in oil use, which now has to average just over 2% per year to achieve the average annual increase in use from 1980 as presented in Fig. 10, the contribution of oil to total world energy supply will fall -- but only very slowly in the context of an overall energy-use growth rate of 2.2% per year up to 1990, 2.4% in the 1990s, and 2.5% after the year 2000. The relationship of oil to other sorts of energy supply over this 30-year period is shown in Figs. 11 and 12. Oil's contribution falls from 46% in 1980 to about 38% by 2010. Incidentally, the increasing share of natural gas in the total supply of energy over this period, as a result of plentiful resources and its availability in the main energy-consuming areas at below oil-equivalent prices, will multiply the volume of gas used by 2010 to three times its 1980 level. Thus the share of oil and gas, which together may reasonably be said to constitute the "petroleum industry," will remain more or less constant, at just under two-thirds of the world's total energy supply.

This availability of low-cost, lower-priced gas will, of course, exercise a powerful downward pressure on the oil price, and this effect on oil will be enhanced by the similar impact of competitive coal in the energy marketplace. Coal supply and use will double over the 30-year period and coal's share of the total energy market will increase slightly. On the other hand, primary electricity and heat from nondepletable resources seem unlikely even to maintain their share of total energy supply under the set of values described in this paper. Their too-high capital and other costs, plus the question of the public acceptability of some alternative sources of energy -- notably, of course, nuclear power -- relative to the lower costs of developing adequate oil, gas, and coal supplies, and to the falling real price of oil (and other competing energies) in the 1980s, will undermine the viability of investment in primary electricity production and other alternative sources.

In essence, the world's energy system in 2010 will still be very much a hydrocarbon-dominated one -- with, at that time, almost 35 years of growth for oil and even longer for gas still to come; and with oil and gas available at prices ranging from less than half to no more than three-quarters of their prices in 1980. Even then there will be plenty of time for alternative energies to

be researched, commercialized, and slowly incorporated into the modestly expanding global energy economy. For the rest of this century at least, it would be preferable to concentrate investment of scarce capital and managerial and scientific resources in the oil and gas sector of the global energy economy: the rates of return to such investment will be much greater than its investment in nonoil and nongas developments. Thereafter, the balance of allocation will slowly change and eventually create the possibility of alternative sources of energy being available in sufficient volumes and at low enough prices to curb the need for, or the desirability of, producing and using the world's least accessible -- and, hence, the highest cost -- oil and gas resources.

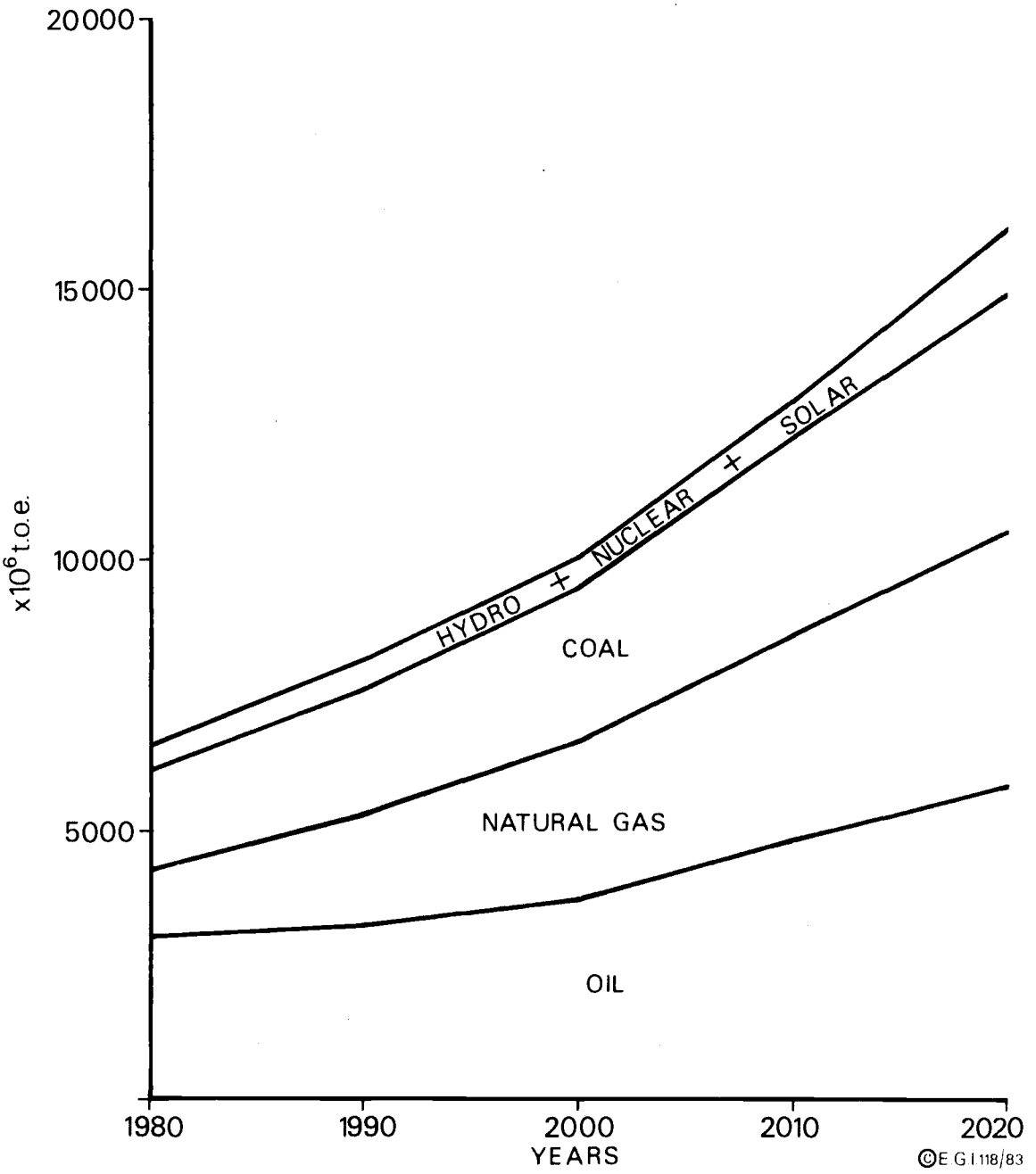

Fig. 11. Energy supply (tonnes of oil-equivalent x 10^6) from various sources, 1980-2020.

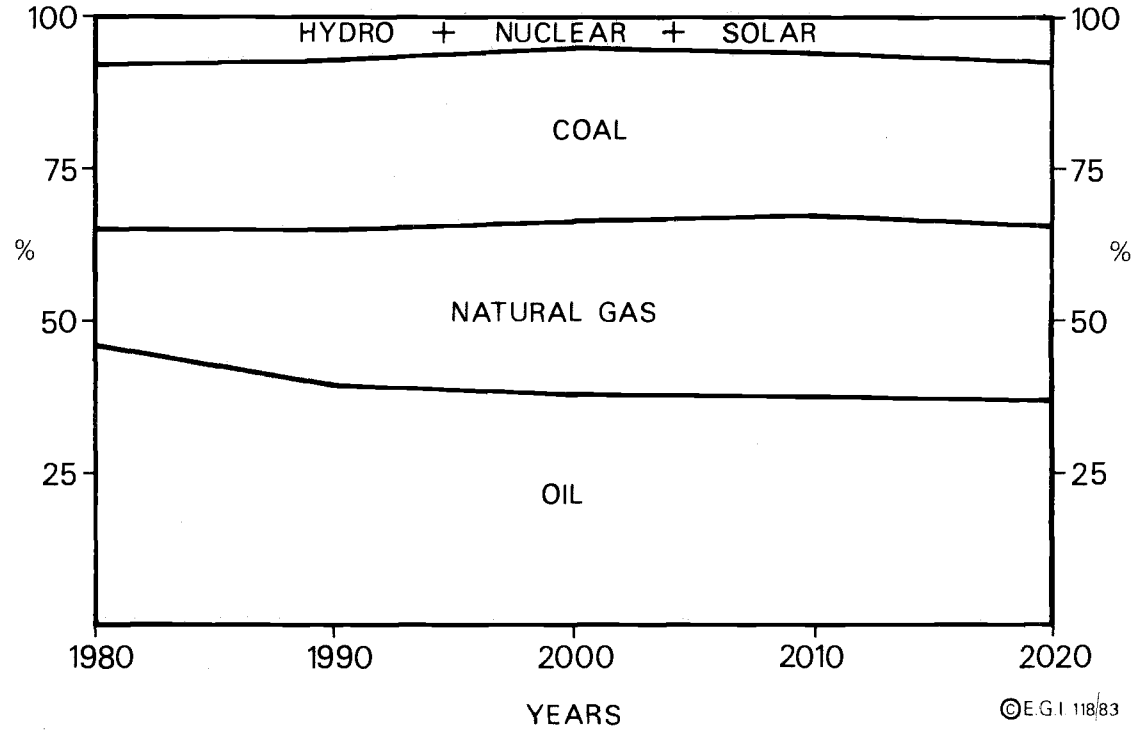

Fig. 12. Distribution (%) of energy supply from various sources, 1980-2020.

Implications for Developing Countries

Several important implications that emerge from this analysis of the nature of the oil crisis are specific to the interests and the policy options of the world's developing countries. These are set out below in a highly tentative way.

If, as we concluded, the price of internationally traded oil continues to decline from the peak prices of late 1981-early 1982, then the foreign exchange and associated debt problems of the poor, oil-importing countries will be mitigated. Moreover, with a continuing fall in real oil prices, the prospects for the western world's economy will be improved with a resultant improvement in the level of demand from abroad for other goods and services supplied by the developing countries. Finally, moderation on the upward pressures and pressures generated by the falling price of oil (and energy) will add yet a further stimulus to the developmental prospects of many Third World countries. Thus, any feeling of solidarity in developing countries for OPEC's attempts to maintain today's high oil prices must be tested in the context of the economically favourable effects of lower oil prices for the nonoil-exporting Third World nations.

The moderation of the level of oil prices depends, as we have shown, on a radical reevaluation of the prospects for oil supply/demand relationships and a better understanding of the real nature of the oil crisis. As so much opinion in the industrialized world is so firm in its acceptance of the conventional view of the future of oil -- partly as a result of the influence of the anti-developmental views of many environmentalists and followers of the "limits-to-growth" school of thought, and partly for reasons of self-interest (e.g.,

protestations of indigenous high-cost energy industry and strategic considerations vis à vis Soviet influence in the Middle East) -- the developing countries' policymakers have an important role to play in changing the climate of opinion and in securing the acceptance of policies that open up a higher probability for energy at lower prices for the medium- to longer-term future.

It is necessary for developing countries to determine whether their interests would best be served by an oil-price collapse to the LRSP (taking into account the likely effects of this on the stability of the world economy, on the motivation for energy efficiency, and on the competitiveness of indigenous energy production) or by a slow, continuing decline in oil prices as predicated in the context of an OECD-OPEC convergent policy (see Fig. 4). If the latter is considered to be a preferable option, then intervention in the OECD-OPEC negotiations would be appropriate to secure a rate of decrease in prices that is calculated to be in the best interests of developing countries, and to ensure that the negotiations are not concluded solely in the interests of the two richer groups of nations, nor without reference to the energy-supply development potential of other parts of the world.

The projections made in this paper on the future of oil depend on demand remaining constrained and on supply potential being enhanced. In the short term, neither development depends very much on policies and action by developing countries.

- On the demand side, the rate of growth in developing countries' use of oil has a minor effect only on the evolution of the overall global situation, given their less-than-20% share of the total world market. For example, a 1% fall in use in the industrial countries more than offsets a 4% average increase in use throughout the developing world where even a 10% per year increase translates into a less than 0.5% per year global increase in oil use -- if demand elsewhere is stagnant. This is advantageous for developing countries' policies towards oil, given the relatively higher contribution of oil to their total energy needs and their lesser immediate ability to change their economies and societies to the use of alternative energies.

- On the supply side, there has been a continuing general weakness of the Third World to expand its upstream oil industry activities. Its share of total world exploration activities has fallen since 1973 and, with a few notable exceptions, development work has continued to be relatively slow and uncertain. This means that additional oil-producing capacity in the 1980s will be located mainly in North America, Western Europe, and Australia. The "notable exceptions" in the Third World will, of course, enjoy increasing benefits from their successful oil development efforts but, overall, this will be of small significance in the global context for the rest of the decade.

In the medium -- and even more so -- in the longer term, the contribution of the developing countries to the future for oil hypothesized in this paper will become relatively more important -- and eventually critical.

Oil use

Given the contrasts between the structures of the energy economies of developing countries and those of countries elsewhere in the world, the proportion of total global use of oil in the former must grow, though how quickly depends mainly on the future shape of the oil-use curve in the industrial countries. Thus, by the mid-1990s at the earliest and soon after 2010 at the latest, the question of the efficiency with which oil is used in the developing countries and the degree to which they are successful in reducing the contribution of oil to their total energy needs will become critical in ensuring the maintenance of a modest global rate of growth in oil use. Success in these respects for the medium to longer term depends, however, on the immediate evolution and the near-future implementation of policies that seek to achieve these objectives. This is necessary to ensure that the emerging patterns of societies and economies do not perpetuate the energy-wasteful and careless settlement, transport, industrial, and electricity production/distribution structures on

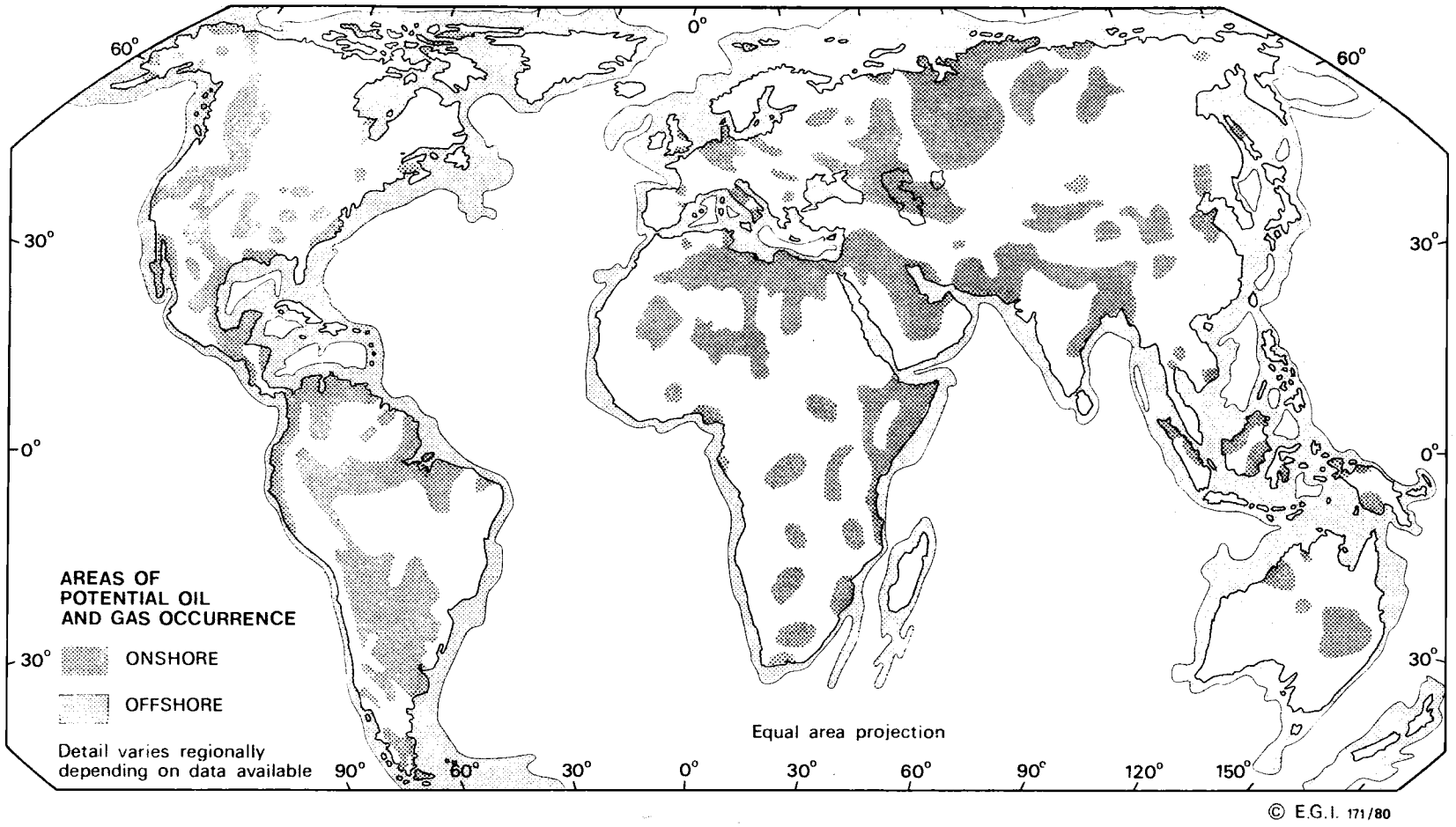

Fig. 13. Areas of potential oil and gas occurrence.

which patterns of development in the industrialized world have been based and which have often, unfortunately, been taken over "lock, stock, and barrel" by developing countries in the initial phases of modernization and change.

The development of efficient and effective energy-using systems is often more capital-intensive and usually less acceptable politically than energy-careless and wasteful systems. It is thus a difficult problem -- with a degree of urgency attached to finding a solution to it, if the world is going to enjoy relatively lower-cost oil over the extended period shown to be possible in this paper.

Oil supply

Figures 13 and 14 put the medium- to longer-term perspectives for future oil-production potential from the Third World into context (see Odell 1981 for a fuller analysis of these issues). In essence, the truth of the present situation is that the oil industry has not yet progressed much beyond its infancy in terms of effective search for the potential for oil production in most parts of the Third World. With about 50% of the global potentially petroliferous areas, the Third World has secured -- and, indeed continues to secure -- no more than 5% of the total worldwide petroleum exploration and development effort. This not only constitutes the most important failure of the world oil industry to date, but it is also the most important challenge facing the industry -- in respect of its upstream activities -- for the future. The background to the intense geographical mismatch between the industry's effort and the opportunities is, moreover, essentially political-economic and geo-political rather than inherently geological. The geological prospects for oil resources in the Third World could be worse to much worse on average than in regions such as North America and other areas that have already been intensively explored without undermining the chances of the developing countries finding more than enough oil (or gas) to meet their relatively limited requirements over several decades.

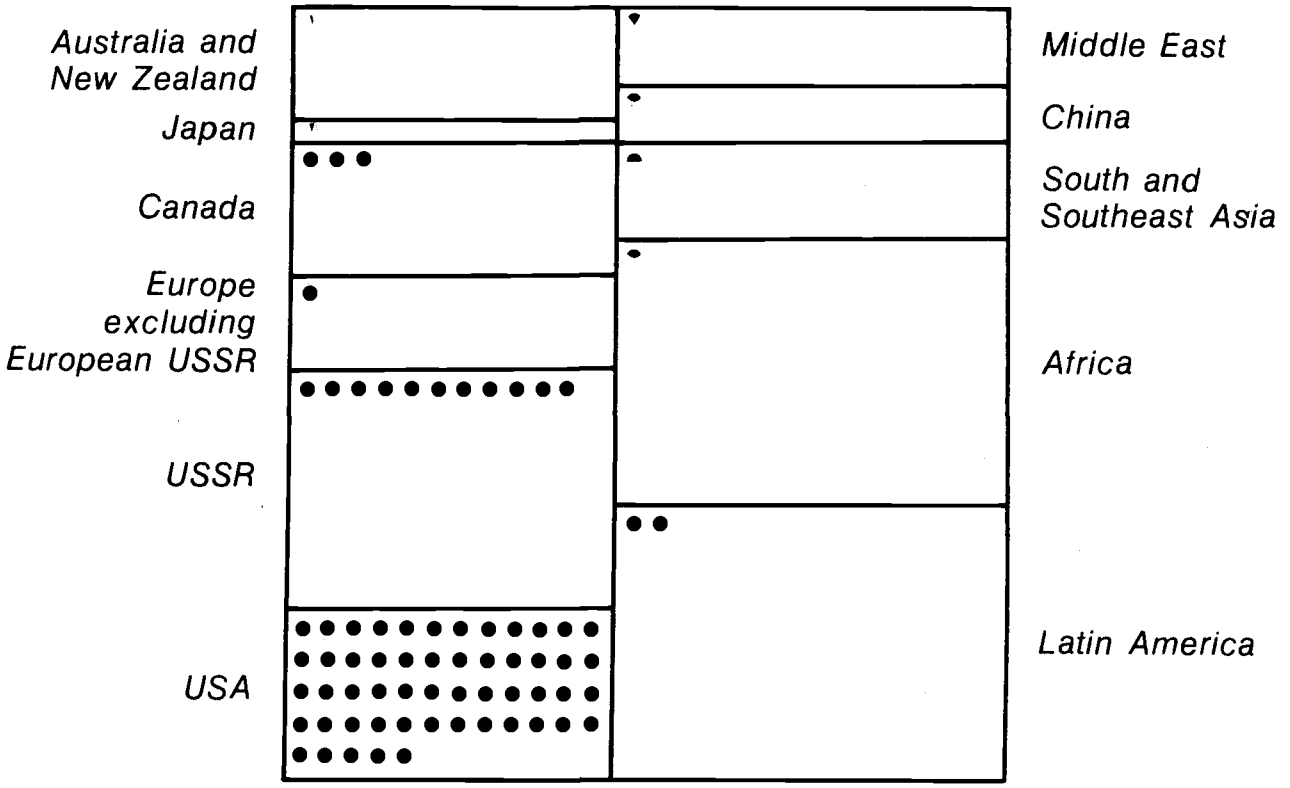

Fig. 14. Oil production potential.

On the one hand, the companies of the world oil industry became largely unacceptable over the years in many countries of the Third World because of fears of economic imperialism. And, on the other hand, the companies themselves have largely written off these potentially petroliferous parts of the world for their investments -- they are simply too risky. Thus, as shown in Table 4, the developing countries' ultimate oil potential is severely understated by the world oil industry -- compared with others with continuing interests in the areas concerned. The companies' disinterest in the opportunities in the Third World is, however, no reason for the potential resources to be declared nonexistent. Revised or entirely new institutional arrangements are required to enable the challenges of the oil opportunities offered by the developing countries to be taken up. The search for acceptable new/revised arrangements must be a high research priority, given the difference that the exploitation of indigenous oil (and gas) resources can make to the longer-term prospects for individual countries' economic development prospects -- and to the future of the global oil industry.

Table 4. Estimates of the ultimate oil resources of the Third World (barrels x 10^9)

	Oil industry views (a)	Grossling (USA) (b)	Visitsky (USSR) (c)
Latin America	150-230	490-1225	686
Africa	120-170	470-1200	730
South and Southeast Asia	55- 80	130- 325	409
Total	325-480	1090-2750	1825

Source: **(a)** Based on figures in Nehring (1978: 88) adjusted to give comparable geographical coverage with (b) and (c) above. Nehring also states (p. 88) that his figures for these regions are "roughly similar" to those published elsewhere by oil industry observers. **(b)** Grossling (1979). **(c)** Visitsky et al. (1977).

Elsewhere (Odell and Vallenilla 1978; Odell 1981), I have set out possible approaches to, and institutional arrangements for, ensuring the sufficient availability of resources (financial, scientific and technical, and managerial) to enable new oil reserves and production potential from the developing countries to complement those that already exist in the OPEC countries (as a result of the activities of the international oil companies over the 30 years before 1973), and those that are now being found in the geographically limited parts of the world where the existing international oil companies, which still control 90% of the appropriate expertise, are able to operate effectively.

What is at stake in responding to the challenge of a geographically more-dispersed pattern of oil and gas exploitation on a large, and increasing, scale is:

- First, the means whereby a large number of developing countries can rid themselves of the specific high-cost constraint of imported oil on their own development prospects; and
- Second, the establishment of conditions for sufficient economic progress and for enhanced and more widespread prosperity in the world economic system generally: a prospect that is, in part, dependent on

the adequate availability of relatively low-cost oil (and gas) resources to energize the expansion. The alternative is having to accept the severe development constraints of either too little energy as in parts of the Third World at the moment, or the too-high costs of changing too quickly to the use of inherently more expensive sources of energy.

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PROSPECTS FOR OPEC OIL IN THE 1980s

Bijan Mossavar-Rahmani

Research Coordinator
International Natural Gas Study
Harvard University
Cambridge, Massachusetts
USA

The OPEC Multiplier: Rebound of World Oil Demand

Throughout the 1980s -- and probably much longer -- the world economy will remain vitally dependent on oil, and most oil-importing countries will continue to be largely dependent on the Organization of the Petroleum Exporting Countries (OPEC), especially on their Persian Gulf sources of supply.

Currently, OPEC is certainly in a crisis; its oil export availability exceeds demand by a wide margin of well over 10 million barrels per day (Mbarrels/day). In some markets, the cost of imported oil has dropped substantially over the past 2 years. However, it is premature to conclude from such developments, as many observers are now doing, that somehow current conditions will become a permanent fixture of the world oil market. Some of these observers are making serious errors of judgment and analysis. Others are seeking to validate their own studies by generating results that fall within the ballpark of prevailing opinion. Still others are drawing long-term conclusions from short-term market conditions. All are allowing the wish to father the thought.

For the process that has sharply reduced OPEC production since 1970 can also cause it to rise quickly -- leading to a tight world market in which oil prices can once again jump substantially. The driving force behind this is a process best described as the "OPEC multiplier." (For a full exposition of the multiplier hypothesis, see Bijan Mossavar-Rahmani "The OPEC Multiplier," Foreign Policy (Fall 1983) from which this section is drawn.)

Behind the drop in energy demand

The concept of the OPEC multiplier -- and its importance in determining likely future trends -- becomes clear within the context of world energy-market conditions. To begin, consider the following trends:

- World primary-energy consumption dropped for the 3rd consecutive year in 1982, reversing the pattern of steady growth that had prevailed through the 1970s. World primary-energy consumption had risen at an average annual rate of 3.9% between 1976 and 1979, but fell 0.7% from the previous year's level in 1980, 0.6% in 1981, and an estimated 1% in 1982.

- The level of world oil production dropped even more rapidly. After rising at an average annual rate of 4.2% in the period 1976-79, it fell 4.9% from the previous year's level in 1980, another 6.9% in 1981, and yet another 5% in 1982.

- The most dramatic reversal has occurred in OPEC oil production. OPEC oil production rose at an average annual rate of 3.4% between 1976 and 1979, but fell 12.9% from the previous year's level in 1980, 16.4% in 1981, and 18.2% in 1982.

The OPEC multiplier explains this cascading pattern of reductions, and is central to understanding the future evolution of the world oil market. The overall decline in world primary energy consumption since 1979 has been attributed to three factors:

- First, irreversible conservation, or improved energy efficiency, which has resulted from the turnover of capital stock. It is embodied in more efficient cars, more efficient buildings, and new industrial processes. Because such conservation occurs in response to higher prices, it is called a price effect.

- Second, reversible conservation, which has resulted from behavioural changes such as turning down thermostats or using car pools. This, too, is a price effect.

- Third, economic recession, which has led to a substantial slump in industrial activity worldwide in the past 3 years. Reductions in energy use in response to lowered national incomes are known as income effects.

To sort out and quantify the contribution of each of these factors is not easy, and their impacts differ from country to country. True, many energy analysts attribute about half the observed reduction in world primary-energy consumption to price effects, primarily irreversible conservation. They credit the other half to a mixture of other factors, such as income effects, climate, and government policies. Some prominent analysts have gone even farther, attributing as much as three-quarters of the recent decline to conservation.

These analysts have probably overstated the post-1979 conservation effects, however, and underestimated the effects of the recession on world primary-energy consumption. If so, the implications are far-reaching for world energy markets.

Indeed, the income effects much outweigh the price effects. Irreversible conservation is a long-term matter. The demand for energy is relatively insensitive to price changes in the short term. The full effects of higher energy prices take place over a 10- to 15-year period (sometimes longer), as energy-using equipment and buildings are gradually replaced in what is often referred to as a process of structural adjustment. The effects of the 1973-74 oil-triggered increases in world energy prices are now beginning to be felt, for instance in the turnover of the American automobile fleet, although they have had hardly any meaningful impact on the housing stock. The structural changes resulting from the 1978-79 increases in energy prices will not be completed until the late 1980s and early 1990s.

Moreover, high interest rates and recession over the last 3 years have impeded some of the long-term investment in irreversible conservation that was expected in 1979 and 1980. The changed expectation about oil prices is having a further dampening effect.

Higher energy prices did, of course, prompt some immediate savings through behavioural changes, such as reduced driving or thermostat lowering. However, these gains are at least partly reversible in a period of declining real energy prices.

In any event, the bulk of the short-term reductions in energy use -- well over half of the total -- should be attributed not to such long-term or short-term price effects, but rather to the deep recession because energy consumption is very responsive to the level and direction of economic activity. Indeed it has been estimated that if everything else were held constant (prices, climate, government policy, etc.), a 1% increase (decrease) in world economic output would roughly translate into a 1% increase (decrease) in world primary-energy consumption. The response of primary-energy consumption to changes in the level and direction of prices is less pronounced; if everything were held constant, a 1% increase (decrease) in prices would roughly translate into a 0.1% decrease (increase) in primary-energy consumption in the short run and a 0.3% decrease (increase) in the long run.

Impact on OPEC

The recession does not, however, explain why world oil production has fallen more rapidly than overall world primary-energy consumption. The explanation for this lies in what can be described as the residual fuel phenomenon -- a driving force behind the OPEC multiplier.

In the 1960s, oil was generally regarded as the most favoured energy source. It was cheap, plentiful, and convenient to transport and use. The situation has of course changed since then, triggered in large part by the 1973-74 Arab oil embargo and subsequent oil-price hikes. In many of the largest energy-consuming nations, from a public policy point of view especially, oil is now generally viewed as the least desired of the primary energy-supply sources. It is either more expensive than its alternatives or or is largely imported and thus considered to be an insecure fuel, or both. Hence, when energy demand is on the rise, indigenous energy supplies (e.g., hydroelectric power, coal, nuclear power, or natural gas) are first tapped to meet that increase. Only then do most consuming countries turn to oil. Similarly, when energy demand falls, it is oil that is usually dropped first.

This description admittedly simplifies what is often a very complex set of interfuel relationships, for example, oil cannot be readily replaced in some uses, such as transportation. However, the description nonetheless underscores the residual role played by oil in the world energy regime.

The extent of oil's residual role is brought home by a single fact: all of the reductions in world primary-energy consumption during the past 3 years have been borne by just that one fuel -- oil. In 1980, 1981, and 1982, world production of hydroelectricity, coal, nuclear power, and natural gas continued to grow, although at lower than historic rates. Because oil is only one component of world primary-energy consumption, a small percentage decline in world primary-energy consumption resulting from a slowdown in world economic activity thus translated into a much larger percentage decline in world oil production.

What accounts for the even sharper decline in OPEC oil production since 1979? The answer lies in the multiplier effect. Much as oil is the residual fuel in the world energy system, so too OPEC is the residual source of world oil supply.

It is only after indigenous oil supplies -- where available -- are produced at capacity levels that countries turn to foreign sources of supply to meet additional needs. Most countries -- and certainly the industrial countries that account for the lion's share of world oil consumption -- first turn to such non-OPEC suppliers as Mexico, Norway, and even the Soviet Union (currently among the world' three largest oil exporters), either because of considerations relating to price or security of supply. Only then do consumers finally turn to OPEC as the supplier of last resort to meet residual needs. Conversely, as oil demand begins to decline, whether as a result of falling economic activity or rising prices, or both, OPEC oil is the first to be droped. In short, a small increase, or decrease, in world oil demand results in a disproportionately large percentage increase, or decrease, in demand for OPEC oil. This is the OPEC multiplier at work.

A few numbers illustrate this phenomenon. OPEC oil historically has accounted for about 50% of world oil production. If, during a period of declining world oil demand, OPEC oil were treated like any other, then a 5% decline in world oil production would result in a 5% reduction in OPEC production. If all the decline is borne by OPEC as the residual supplier, however, then a 5% decline in world oil production leads to a 10% decline in OPEC output.

Cycles repeated

The significance of this multiplier effect is that it not only works but works in reverse as well. Thus, even a small percentage increase in world economic activity and a concomitant increase in primary energy consumption in each of the next several years could lead to a much larger percentage increase in world demand for OPEC oil -- one far greater than most analysts consider possible today.

If so, the market would merely be repeating what was a pattern of the 1970s. Between 1971 and 1973 -- the last "normal" year before the first oil price shock -- world gross domestic product (GDP) rose at annual rates of 4.3, 5.6, and 6.7%, respectively, while OPEC oil production climbed at rates of 8.2, 7.0, and 14.4% -- in multiplier fashion. With the onset of global recession in 1975 and an increase in production of nonoil energy supplies generally, and non-OPEC oil supplies specifically, OPEC oil production plunged. Once economic recovery got underway in 1976, a 5.4% rate of growth of world GDP translated into a 12.9% increase in demand for OPEC oil. The reverse side of the OPEC multiplier was clearly demonstrated.

These effects were less evident in 1977-78 because of increases in production outside OPEC (most notably in Mexico, Alaska, the North Sea, and the Soviet Union). Conversely, these effects have been more pronounced since 1980 given substantial net drawdown of oil stocks by the international oil companies. High interest rates and changed expectations about price, demand, and supply have created an imperative for the companies to unload large inventories, built up during the Iranian revolution, which they have been doing at a rate that at times has reached 3-4 Mbarrels/day (Fig.1).

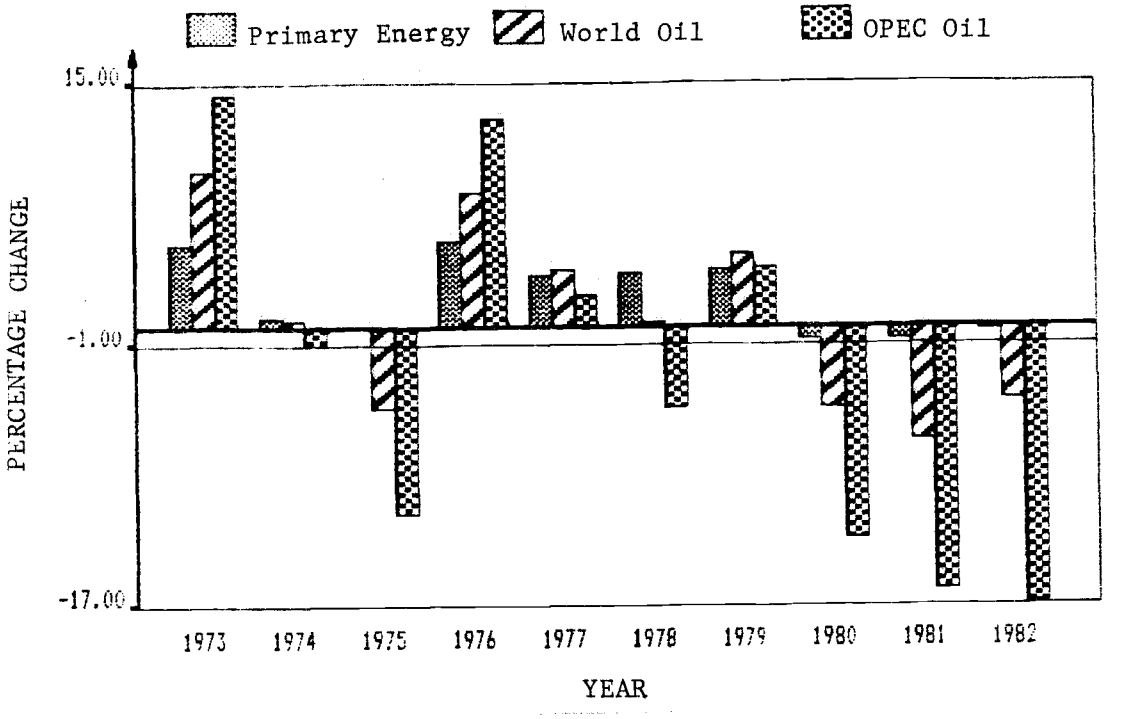

Fig. 1. OPEC multiplier effects, 1973-82.

OPEC is the residual supplier of energy to the rest of the world. As such, it is the supply source most profoundly affected or multiplied by swings, downward or upward, in world energy markets. Once global economic growth and primary energy consumption pick up, say in 1983, the resulting recovery in OPEC oil production could be disproportionately large. Indeed, falling oil prices might even help trigger a more rapid rate of economic recovery than has been thought possible. Falling real oil prices during a period of rising economic growth will mean that the price and income effects will reinforce each other, and together work to stimulate oil demand.

Two additional forces work to bolster future demand for OPEC oil. First, falling real oil prices have already discouraged investments in a wide range of energy sources, including natural gas, synthetic fuels, shale oil, nuclear power, and even oil itself. Second, no major new sources of oil are in sight for the rest of the 1980s. Three new oil provinces -- Mexico, Alaska, and the North Sea -- added 6 Mbarrels/day of supply to the world market between 1973 and 1981. Some increases in Mexican production notwithstanding, no further additions on this scale will come on stream in this decade.

Shock zones

The same forces that drove down demand for OPEC oil could drive it back up again -- perhaps in as short a time. By the latter half of this decade, world demand for OPEC oil could recover to its pre-1980 level of 30 Mbarrels/day -- well within the "shock zone" in which even a small short-lived disruption in supplies could set off the third oil price spike in just over 12 years.

A first ingredient of a scenario for rapid recovery in demand for OPEC oil would be a rate of world economic growth well within the range currently projected for the rest of the decade. At about 3% annual growth of GDP (slightly lower for the industrial countries and somewhat higher for the developing ones), world energy demand will also grow at about the same rate, especially during the first years of recovery. Whatever savings occur during this period as more energy-efficient plants and equipment come on stream will be offset -- probably more that offset -- by the increased consumption that will result from rapidly dropping real oil prices. This was the pattern after the 1973 oil shock. Hence, the second ingredient is a weakness in oil prices (in real terms) over the next several years.

OPEC oil prices -- adjusted for reductions in nominal prices as well as for inflation -- have already dropped by 30-40% in the past 2 years, and at least part of these savings have been passed on to final consumers. Real price reductions have been the greatest in the United States, and the smallest in those industrial countries whose currencies have depreciated with respect to the U.S. dollar, the currency in which OPEC oil prices are quoted.

Consider what happens with an economic recovery that is accompanied by only "modest" inflation -- 6-7% per year. This would mean that if oil prices remained unchanged in nominal terms, a further decrease of 20-25% in the inflation-adjusted price over the next 3 years would occur.

Clearly, the dramatic price reductions to date are already creating conditions to stimulate renewed oil use. It is illogical to believe -- as some analysts insist -- that higher prices decrease demand permanently, but that lower prices will not increase it. Although consumers will not jettison vehicles they have already bought, will the U.S. automobile industry, for example, make the planned large investments in future fuel efficiency under current market conditions? Will motorists keep car pooling? Home-owners will not tear out their insulation, but will they keep their thermostats as low in the winter and as high in the summer? Businesses will not give up coal-fired plants if they have already made the investment, but will they make new investments in such facilities? Will industry substitute labour and capital for energy?

To believe the structural thesis, that energy demand is a one-way street, one must also believe a great deal of uneconomic behaviour will occur. However, the rapid recovery of world energy demand in the mid-1970s, resulting from renewed economic growth and falling real oil prices, suggests otherwise.

To repeat, even with an assumption of modest economic growth, by the latter part of the decade the world could face a tight balance between demand for OPEC oil on the one side, and OPEC's physical ability to produce on the other. The world oil market would then, once again, become vulnerable to that volatile mixture of oil and politics that leads to a disruption of supplies and to higher prices.

If past cyclical patterns are repeated, world demand for OPEC oil will drop in the wake of another such price shock; but the market may nonetheless remain tight in the latter half of the 1980s. For OPEC, oil-export availability -- the true measure of OPEC's potential contribution to supplies -- will become permanently constrained for reasons that are outlined below and that require more careful consideration in any serious analysis of future world market trends.

Measuring OPEC Oil-supply Availability

In making estimates of availability of OPEC oil, three basic distinctions predominate, although they appear under different labels. First, **sustainable**

capacity represents an estimation of the maximum level of oil production from each country's oilfields, as well as from the supporting infrastructure, that can be sustained for at least several months. Sustainable capacity estimates do not necessarily reflect how much oil is actually made available for production in individual countries. For that purpose, a separate estimate of preferred production, or **allowables**, is made, based on what is known or surmised about policy ceilings on production below physically sustainable levels.

Estimates of production ceilings -- whether physically fixed or policy constrained -- should not be confused with **export availability**, or that portion of total production left over after domestic requirements for refined oil products are met in each country. Indeed, this last category is the key barometer of OPEC oil availability.

Until recently, few countries either imposed or strictly adhered to policy ceilings on production, and domestic requirements for oil products within OPEC countries themselves accounted for only a tiny fraction of total output. The situation has changed rapidly since the late 1970s, however, and these distinctions need to be carefully made in any study of future OPEC oil-supply availability.

Of course, the amount of oil actually sold by the OPEC countries is a function of world demand in any year within the bounds set by physical limits on sustainable capacity, policy-restricted allowables, and domestic consumption. However, a careful and systematic examination of the determinants of each of these three constraints on OPEC availability will provide clues to the likely future course of the world oil market.

Given information about the physical state of existing oilfields, the political economy of oil production in each country, and the pattern of domestic consumption of refined oil products, it is possible to make reasonably informed estimates of OPEC's sustainable capacity, allowables, domestic consumption, and export availability in the latter part of the 1980s.

Sustainable capacity

Table 1 indicates a base-case estimate of OPEC's sustainable capacity levels through the end of the decade. Despite uncertainties surrounding future

Table 1. Projected OPEC sustainable oil production capacity to 1990 (millions barrels daily)

	1982	1985	1990
Saudi Arabia	10.00	10.00	11.00
Iran	3.00	3.50	5.00
Iraq	2.00	2.50	3.50
Kuwait	2.50	2.50	2.50
United Arab Emirates	2.50	2.50	2.50
Qatar	0.60	0.55	0.50
Persian Gulf	20.60	21.55	25.00
Nigeria	2.20	2.10	2.00
Libya	2.00	2.00	2.00
Algeria	1.00	0.90	0.70
Gabon	0.20	0.20	0.20
Africa	5.40	5.20	4.90
Venezuela	2.30	2.20	2.00
Ecuador	0.25	0.25	0.20
Latin America	2.55	2.45	2.20
Indonesia	1.60	1.50	1.40
TOTAL OPEC	30.15	30.70	33.50

sustainable capacity, all estimates in this table (and, in fact, estimates in all ensuing tables) have been expressed as single figures rather than as ranges. Ranges, although admittedly more realistic in their caution (economic and political vagaries in each country as well as other unpredictable events might alter the individual projections for any given year), provide a less tangible base for meaningful discussion.

Uncertainties over future sustainable capacity are greatest in the Persian Gulf countries and least so in the rest of OPEC. It should be pointed out, however, that the estimates for Saudi Arabia and Iraq are somewhat lower, and those for Iran somewhat higher, than estimates by other analysts.

OPEC's sustainable capacity will thus rise by 0.6 Mbarrels/day to 30.7 Mbarrels/day in 1985 and by another 2.8 Mbarrels/day to 33.5 Mbarrels/day in 1990. The only increases by 1985 will occur in Iran and Iraq whose production levels today remain severely depressed because of war, and whose oil-sector development programs have been deferred until cessation of hostilities. Sustainable capacity in 1985 is all countries will not change significantly.

By 1990, sustainable capacity levels in Iran and Iraq will be further enhanced by postwar reconstruction of oil infrastructure, and Saudi Arabia, too, will have added about 1 Mbarrels/day to its sustainable capacity. With the exception of Algeria and Venezuela, which are projected to suffer a small decline (0.2 Mbarrels/day each), sustainable capacity levels in the remaining countries will again remain basically unchanged.

Allowables

In the future, as in the past, several OPEC members are likely to retain ceilings on how much oil will be availabe for production. Specifically, three countries -- Saudi Arabia, Kuwait, and the United Arab Emirates -- are expected to maintain allowables, primarily in response to domestic conservationist sentiment, and also because, even at these levels, revenues from oil sales will remain at comfortable levels.

Table 2 lists likely allowables for OPEC countries to 1990 under a "business as usual" scenario. This qualification is important to make because such

Table 2. Likely OPEC oil production allowables to 1990 (million barrels daily)

	1982	1985	1990
Saudi Arabia	8.80	8.50	8.50
Iran	3.00	3.50	5.00
Iraq	2.00	2.50	3.50
Kuwait	1.50	1.50	1.80
United Arab Emirates	1.50	1.50	2.00
Qatar	0.60	0.55	0.50
Persian Gulf	17.40	18.05	21.30
Nigeria	2.20	2.10	2.00
Libya	2.00	2.00	2.00
Algeria	1.00	0.90	0.70
Gabon	0.20	0.20	0.20
Africa	5.40	5.20	4.90
Venezuela	2.30	2.20	2.00
Ecuador	0.25	0.25	0.20
Latin America	2.55	2.45	2.20
Indonesia	1.60	1.50	1.40
TOTAL OPEC	26.95	27.20	29.80

ceilings on production can be introduced or lifted quickly in response to a wide range of political, economic, and diplomatic considerations and will remain the most flexible of the constraints on OPEC oil availability.

Domestic consumption

Domestic oil consumption in the OPEC countries will continue to climb steadily (Table 3) and, as a consequence, OPEC oil-export availability (see Table 4) will begin to shrink by the end of the decade as these countries use up an increasing share of their total output. The average annual rate of growth of OPEC's oil consumption is thus estimated at about 5.5% between 1980 and 1990, a rate higher than that projected for the rest of the world. This higher growth rate in future oil consumption reflects expectations that the OPEC economies will grow more rapidly, given these countries' access to secure and lower-cost oil for use at home on the one hand, and the continued large flow of revenues from the export of the balance of their production on the other.

However, even the OPEC countries are becoming increasingly aware of the need for energy -- and particularly oil -- conservation. Until recently, domestic fuel prices had remained largely unchanged in nominal terms in many OPEC countries due to considerations of politics (considerable public opposition to price hikes), economics (subsidies to export industries and the agricultural sector), and equity (cheap fuel for the urban and rural poor). With rapid growth in domestic oil consumption in the 1970s and prospects for ever-shrinking export availability, however, many OPEC governments felt they had no choice but to embark on price increases. Between 1979 and 1982, at least six OPEC members substantially raised domestic prices for oil products, and some have vowed eventually to reach world price levels.

Table 3. Projected OPEC domestic oil consumption to 1990* (million barrels daily)

	1982	1985	1990
Saudi Arabia	0.60	0.77	0.98
Iran	0.50	0.76	1.03
Iraq	0.23	0.38	0.49
Kuwait	0.13	0.14	0.16
United Arab Emirates	0.10	0.11	0.21
Qatar	0.10	0.01	0.01
Persian Gulf	1.57	2.17	2.88
Nigeria	0.21	0.23	0.26
Libya	0.10	0.13	0.17
Algeria	0.13	0.13	0.17
Gabon	0.03	0.04	0.05
Africa	0.47	0.53	0.65
Venezuela	0.42	0.43	0.46
Ecuador	0.09	0.10	0.15
Latin America	0.51	0.53	0.61
Indonesia	0.47	0.52	0.64
TOTAL OPEC	3.04	3.75	4.78

* Includes refinery uses and losses and bunkers.

Higher prices will serve to uncouple, at least somewhat, the historic relationship between economic growth and oil consumption in the OPEC countries, as they have done elsewhere in the past 10 years. At the same time, although some OPEC countries will continue to concentrate on building energy-intensive industries at home, these industries will be based on newer, more energy-efficient, imported technologies, and on nonoil sources altogether, such as natural gas.

Few previous studies of OPEC domestic-oil consumption have considered the effects of these developments on future demand in these countries, and thus they generated projections that were unrealistically high. The first important study, prepared in 1979 by analysts at the OPEC Secretariat itself, for example, projected an almost eight-fold increase in OPEC domestic oil consumption to 16.6 Mbarrels/day by the year 2000. Although this figure was subsequently revised downward, this, and in fact most studies of future OPEC domestic oil consumption, have proved to be deficient in important respects. Several studies simply projected total domestic-oil consumption under various economic growth scenarios for the OPEC countries as a group, thereby neglecting important differences in the growth prospects of individual countries and in those broader government policies that affect energy use. Others did not break down demand by type of refined product; the pattern of current and future product demand varies considerably from country to country. Some studies included refinery fuels and losses and bunkers, while others excluded this important component of total oil use. Most ignored the dampening effects of higher domestic oil prices on future demand.

After attempting to correct these deficiencies, the projections of 1985 and 1990 domestic OPEC oil consumption presented here fell significantly below most other published estimates. These projections of future OPEC domestic oil consumption are, nonetheless, sufficiently high to influence the future course of the world oil market as well as economic development prospects in individual countries. As indicated in Table 3, OPEC domestic-oil consumption, including refinery fuels and losses and bunkers, is projected to grow from about 3.0 Mbarrels/day in 1982 to 3.8 Mbarrels/day in 1985 to 4.8 Mbarrels/day in 1990.

Export availability

In 1982, total OPEC oil export availability stood at 23.9 Mbarrels/day out of a sustainable capacity level of 30.2 Mbarrels/day and an allowable level of about 27.0 Mbarrels/day. By 1985, the corresponding figures are projected at 23.4, 30.7, and 27.2 Mbarrels/day respectively, assuming that Iran and Iraq re-enter the world oil market in the next couple of years. Some time after mid-decade, however, OPEC oil export availability will begin to decline -- even with these two key countries producing at peak levels -- as sustainable capacities begin to fall in some countries while, at the same time, domestic oil consumption continues to rise throughout OPEC.

Under the base-case scenarios for allowable and domestic consumption developed above, export availability (Table 4) is projected to decrease over the course of the decade in every OPEC country with the notable exception of four: Iran, Iraq, Kuwait, and the United Arab Emirates. The decline in export availability between 1982 and 1990 will be the most dramatic in five countries: Saudi Arabia (down by 0.67 Mbarrels/day), Algeria (0.44), Venezuela (0.44), Indonesia (0.37), and Nigeria (0.25).

Thus, by 1990, OPEC oil export availability will total only 25.0 Mbarrels/day out of an aggregate sustainable capacity of 33.5 Mbarrels/day and an allowable level of 29.8 Mbarrels/day.

What is perhaps an even more important feature of this scenario is the composition of export availability or the increasing concentration of supply in the Persian Gulf region generally, and in particular within three countries whose future political configuration -- and hence oil supply and pricing policies -- are most uncertain: Saudi Arabia, Iran, and Iraq. Together these countries will account for 14.5 Mbarrels/day or 58% of OPEC's total oil export availability by 1990 in the base case projection (against 52% in 1982 and 54% in 1985).

Table 4. Projected OPEC oil export availability to 1990 (million barrels daily)

	1982	1985	1990
Saudi Arabia	8.20	7.73	7.53
Iran	2.50	2.74	3.97
Iraq	1.77	2.12	3.01
Kuwait	1.37	1.36	1.64
United Arab Emirates	1.40	1.39	1.79
Qatar	0.59	0.54	0.49
Persian Gulf	15.83	15.88	18.43
Nigeria	1.99	1.87	1.74
Libya	1.90	1.87	1.83
Algeria	0.87	0.76	0.53
Gabon	0.17	0.16	0.15
Africa	4.93	4.66	4.25
Venezuela	1.88	1.77	1.54
Ecuador	0.17	0.15	0.05
Latin America	2.05	1.92	1.59
Indonesia	1.13	0.98	0.76
TOTAL OPEC	23.94	23.44	25.03

This shifting focus of OPEC oil export availability to the Persian Gulf has far-reaching implications for the stability of world oil supplies and, consequently, for world oil prices. Politically, the Persian Gulf region is among the most volatile in the world; its countries are not only prone to internal upheaval but also to external threats of aggression. The inherent instability of this region has been further compounded by the pressure of world reliance on its oil.

The oil problem thus remains the same. It is the threat of political upheaval in the Persian Gulf that translates into supply interruptions and economic chaos. The later any supply disruption occurs, the greater its impact on oil prices; the world oil market will become increasingly tight with each passing year as OPEC oil export availability continues to taper off.